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EDITED BY THURSTON SCOTT WELTON, M.D.

September 1945

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Fifty-fourth Year of Continuous Publication

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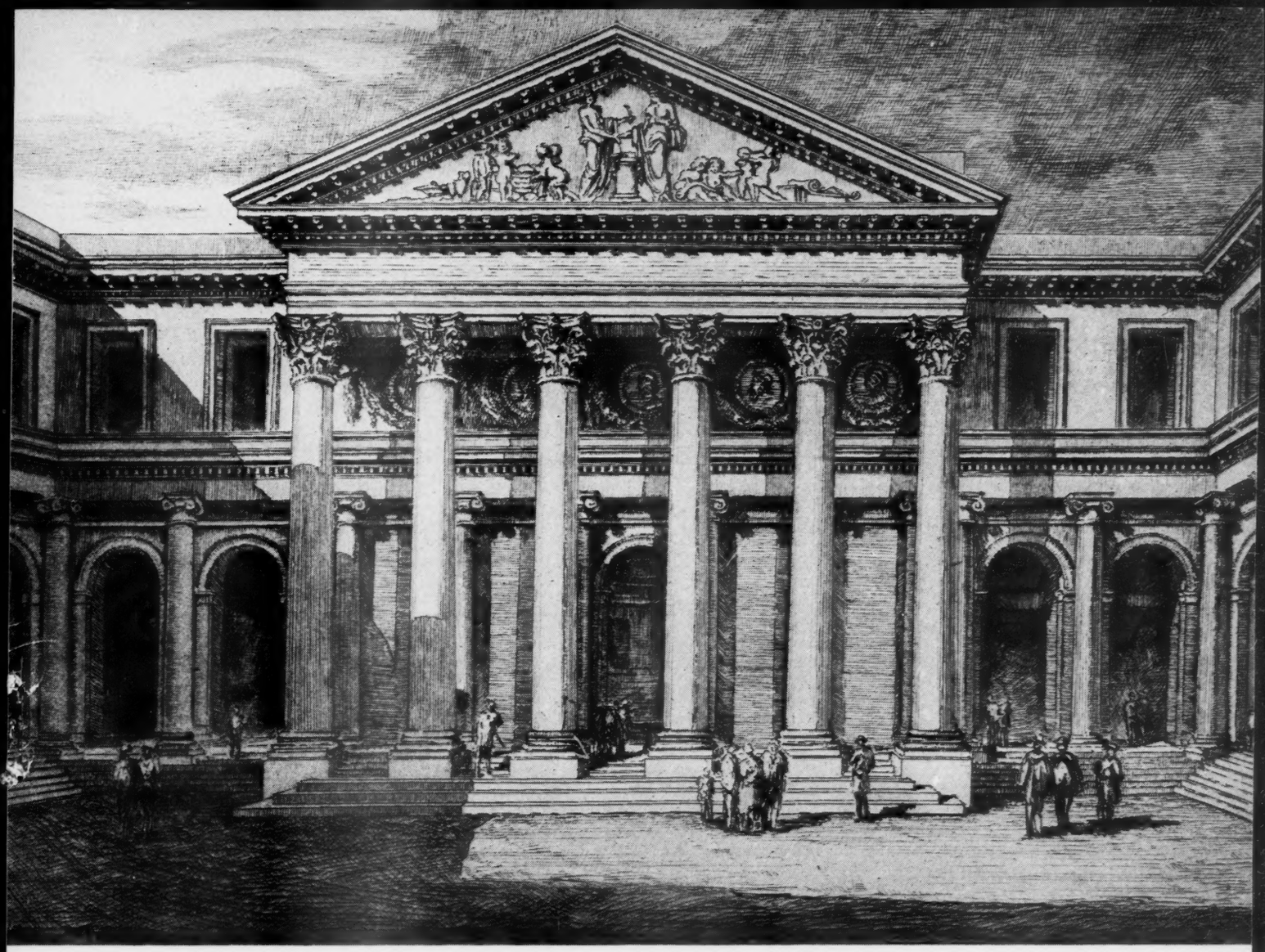
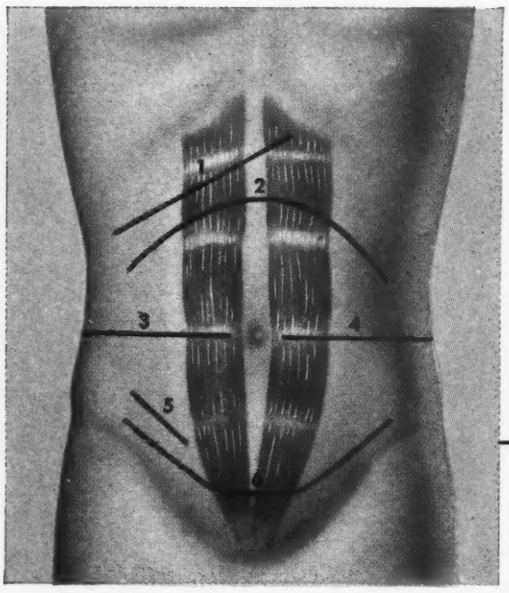


FACULTY OF MEDICINE, UNIVERSITY OF PARIS — The history of this famous medical school covers nearly seven hundred years of medical instruction. Probably the span is greater, since it is known that teaching was begun many years before the Faculty of Medicine was officially designated as a part of the University of Paris in 1281. Among the teachers, graduates and research scientists connected with this ancient school appear some of the most illustrious names in the annals of medicine. Today the Faculty of Medicine, with its modern laboratories, occupies these buildings adjacent to the Sorbonne.

Research is the right hand of medicine and surgery. It clears the trails that lead closer and closer to the goals of better health and well being toward which all medical men are striving. One phase of research concerns the development and improvement of sutures. In this field D&G has reached an advanced position, and as a result is constantly helping to increase the range and efficiency of the surgeon's technic by supplying him with better sutures with which to accomplish his purposes.

Incisions that Minimize

AN IMPORTANT ADVANCE IN THE TECHNIC OF SUTURING



1. For gall bladder, common duct, head of pancreas.
2. Resection of stomach, transverse colon.
*3. Resection of ascending colon, cecum, right sided lesions.
*4. Descending colon, spleen and left sided lesions.
5. Appendectomy.
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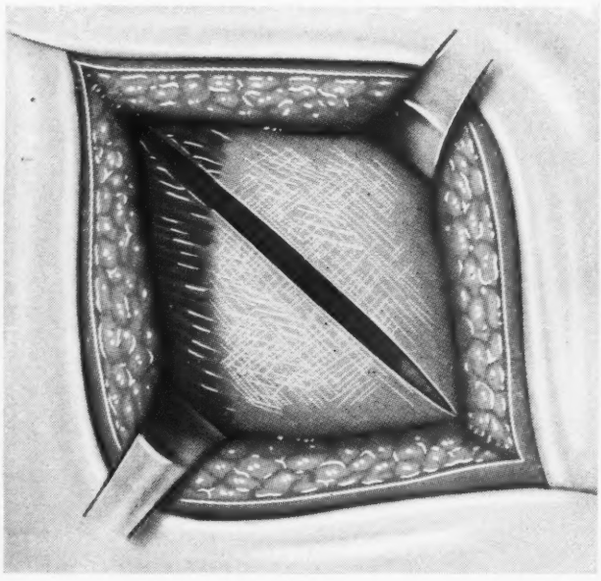
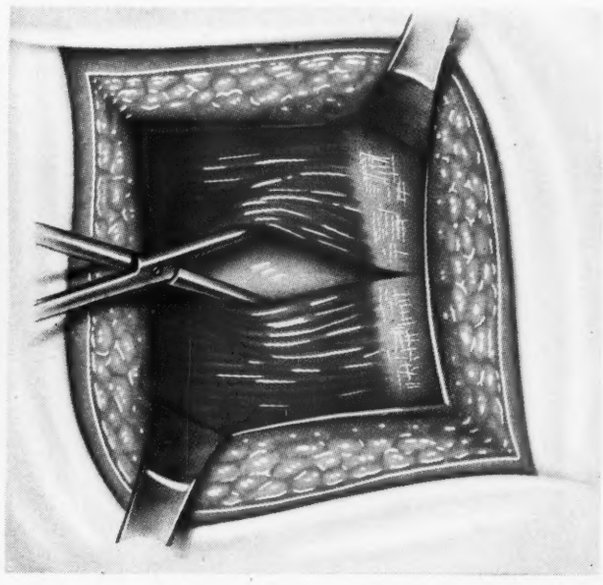
INCISIONS which offer maximal assurance against sutures pulling through the tissues eliminate a principal cause of wound disruption.

Sutures hold most securely if the connective tissues within the wound are approximated in such a manner that the sutures must pull against the fibres within these layers. This is possible only when connective tissues are cut parallel to the direction of their fibres. In the anterior abdominal wall, this is usually best accomplished through a transverse initial skin incision.

In suturing transverse incisions, no attempt is made to suture muscle—only the surrounding sheath. Approximation of the muscle edges is further aided by keeping the patient in a semi-reclining position with knees partially flexed.





Wound Disruption

NUMBER FIVE OF A SERIES

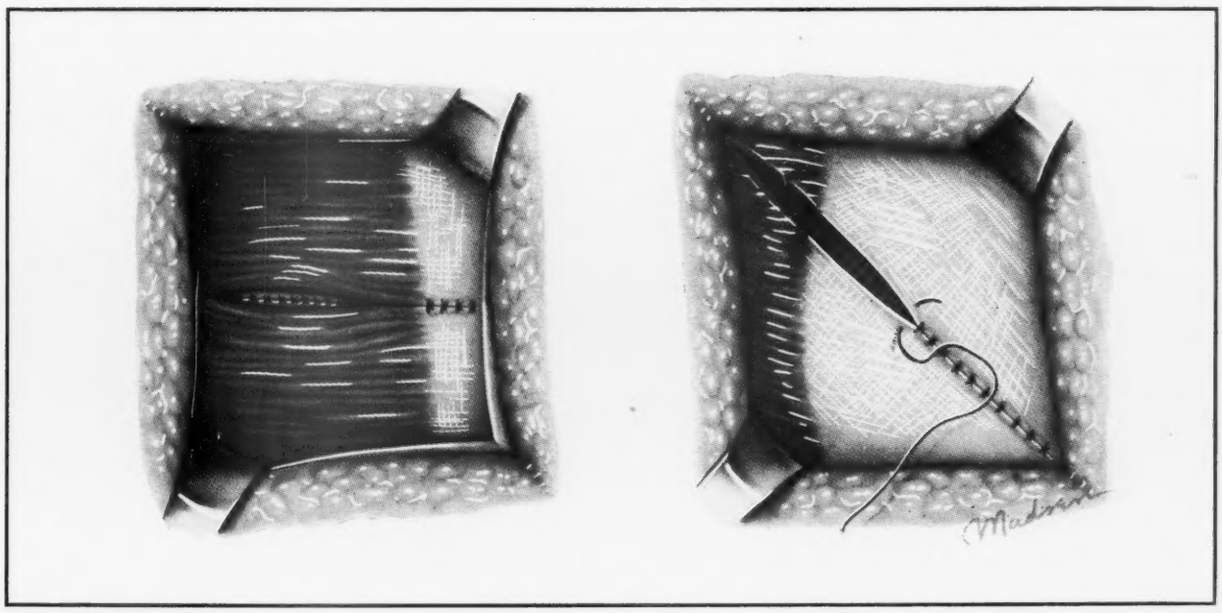
*THE McBURNEY OR GRIDIRON INCISION FOR APPENDECTOMY

The McBurney or gridiron incision employed to remove the diseased appendix is the most widely accepted yet perhaps the most frequently challenged of all incisions. Some surgeons feel that through this small incision, essential pathology may be overlooked and that the inadequate exposure it affords makes intraperitoneal surgery unnecessarily difficult. Others point out that this criticism is not justified since the incision can easily be enlarged to permit further exploration if the condition of the appendix does not explain the presenting symptoms. In addition, they cite the following advantages of the gridiron incision:

1. The retrocecal and lateral cecal appendix is more readily removed through it than through a longitudinal incision.
2. The appendiceal abscess can be drained through it without contaminating the general peritoneal cavity—a very real hazard in the treatment of the appendiceal abscess.
3. Fewer post-operative herniae are claimed for the McBurney incision than for others, and early ambulation was first practiced with this incision.

Wier obtained increased exposure with the McBurney incision by cutting the posterior and anterior sheath of the rectus muscle and retracting the muscle laterally. Since, however, experience has now demonstrated that the recti muscles can be cut without danger of subsequent deformity, the initial incision can readily be converted into a transverse incision across the entire abdomen if desired. This would seem to eliminate all criticism of the McBurney incision.

In making the McBurney incision, the skin should be cut transversely because incisions made in this direction not only spread less than the conventional slanting incision, but permit enlargement if necessary. The external oblique muscle and fascia are split in the direction of their fibres and after these are retracted the internal oblique and the muscle and fascia of the transversalis and peritoneum are cut horizontally. To enlarge the incision, the interior epigastric vessels are ligated and the rectus muscles and their sheaths are cut transversely. As with all the other transverse incisions, only the fasciae are sutured and all sutures pull against the fibres of the tissues.



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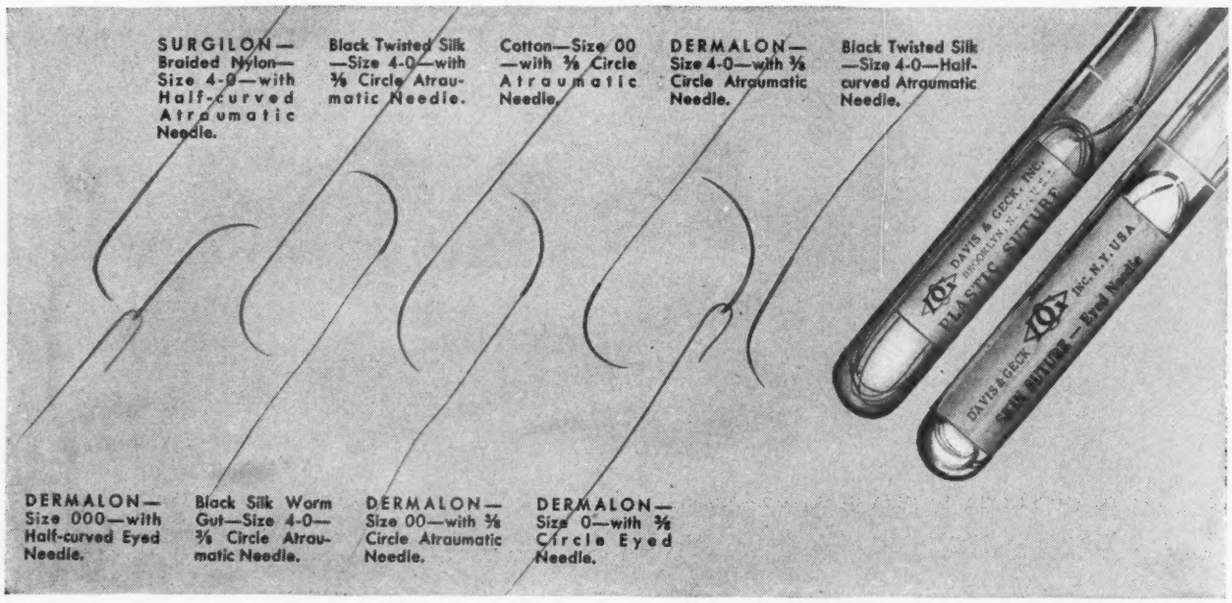
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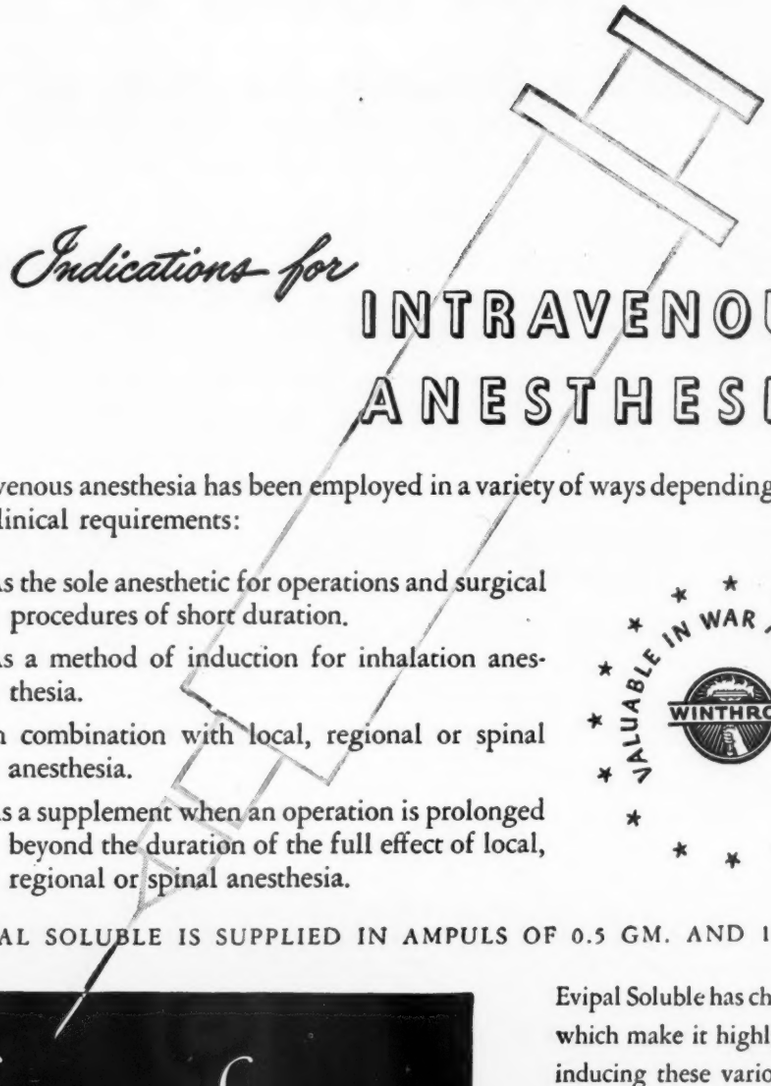

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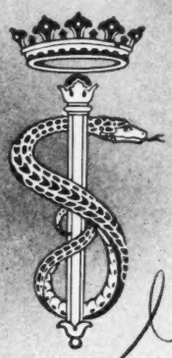

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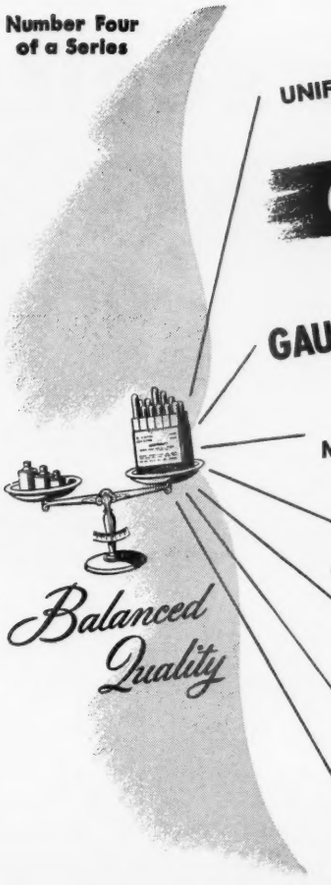

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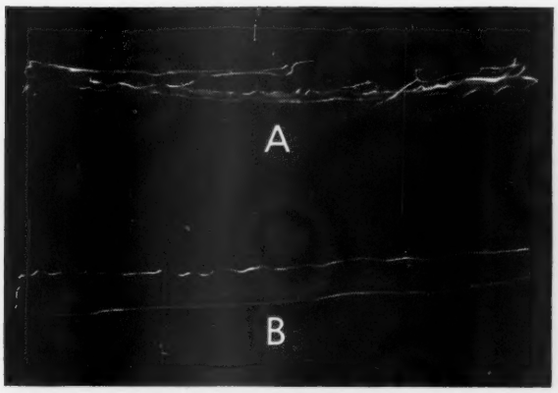
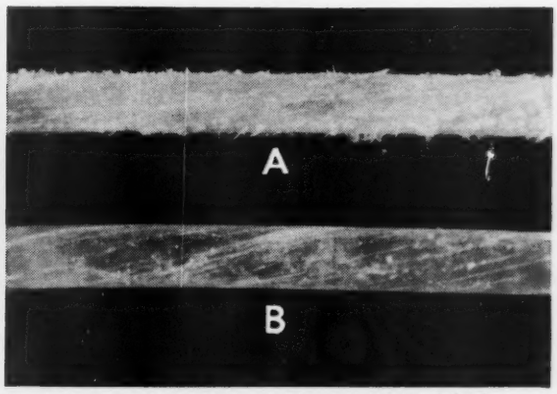


Untwisted plies recovered from two catgut strands polished to different degrees.

A—Ply or ribbon, recovered from an overpolished suture strand. B—Ply from Curity strand not polished to gauge.



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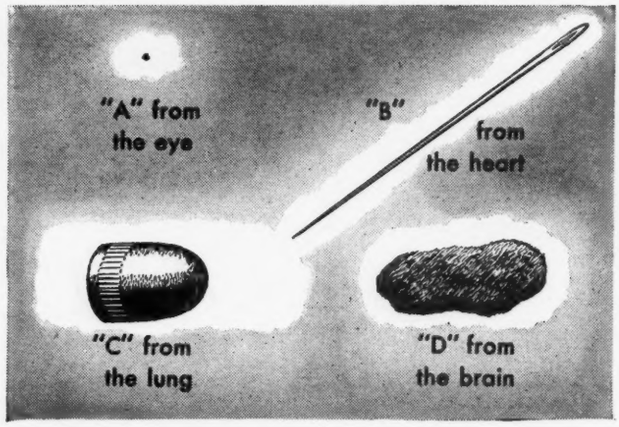

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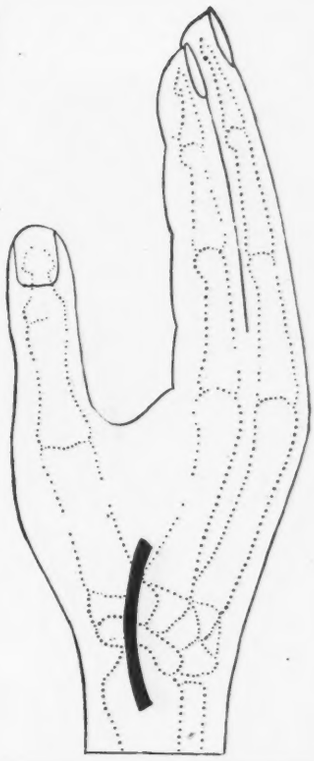

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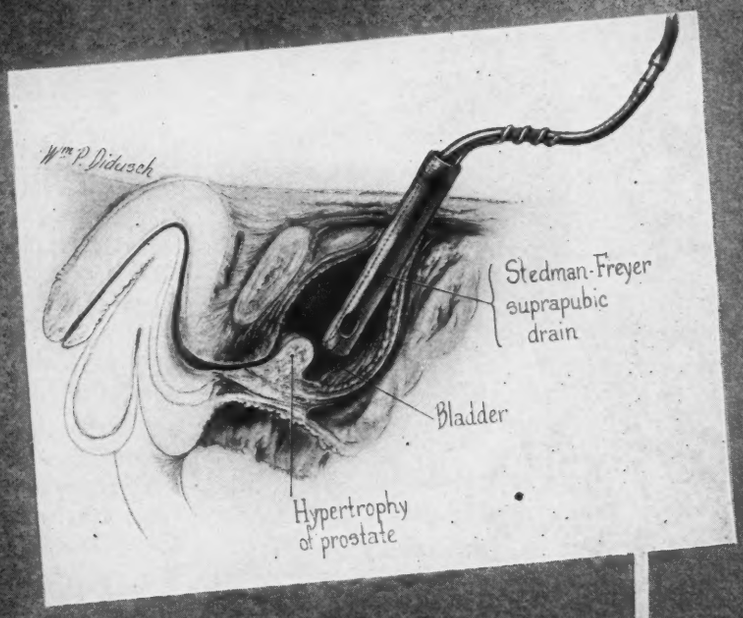

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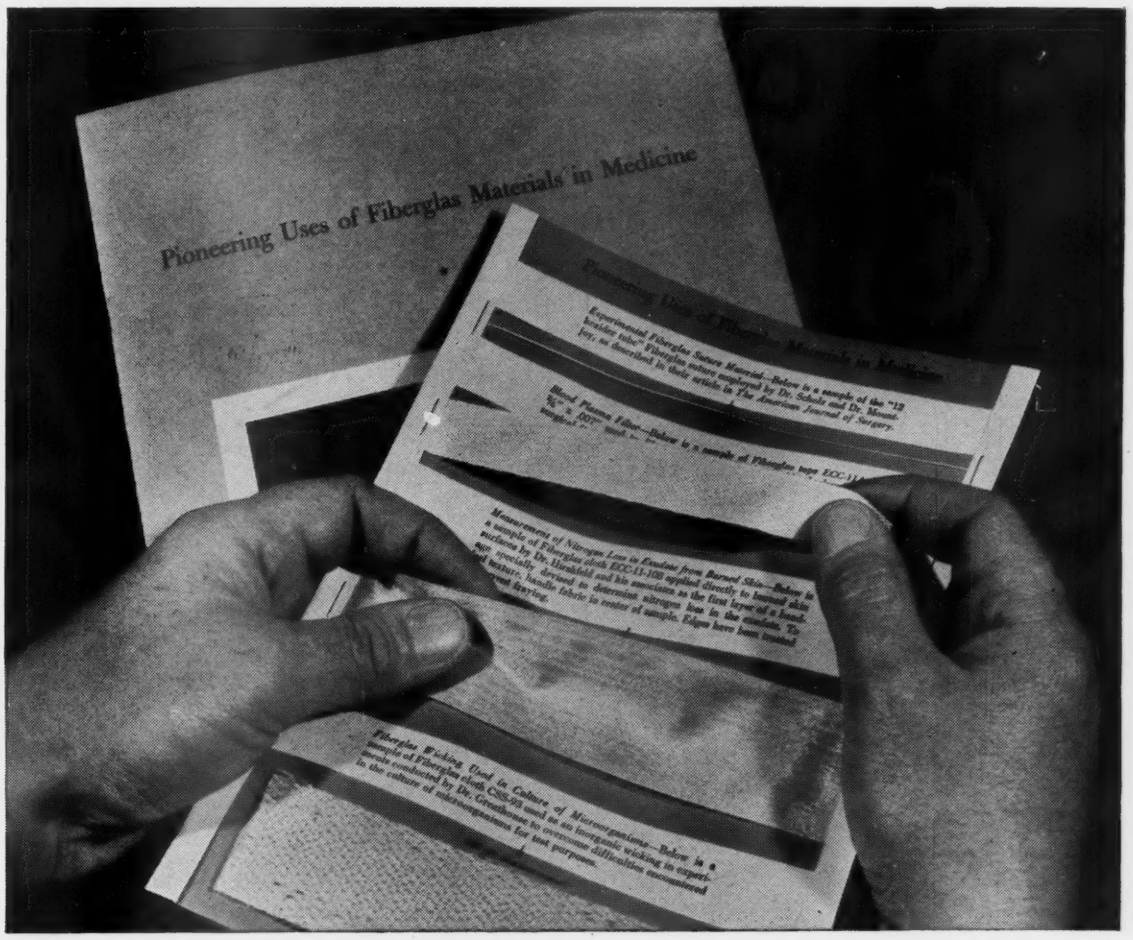

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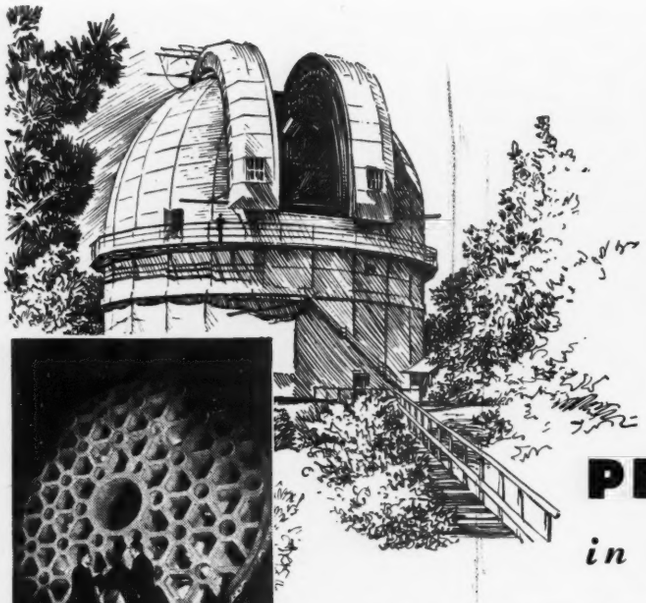

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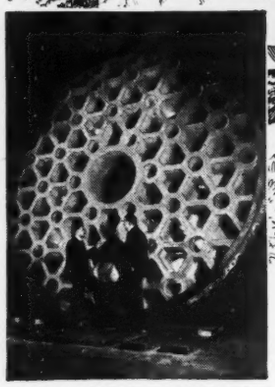

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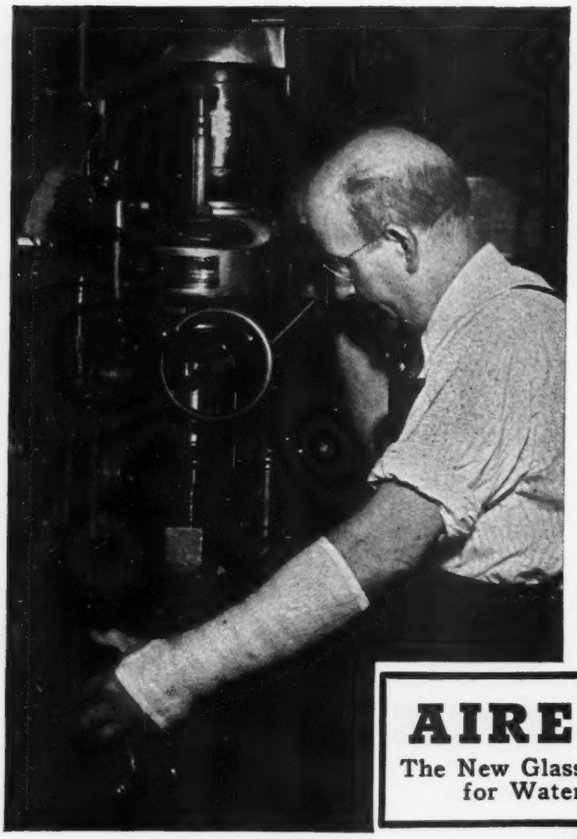

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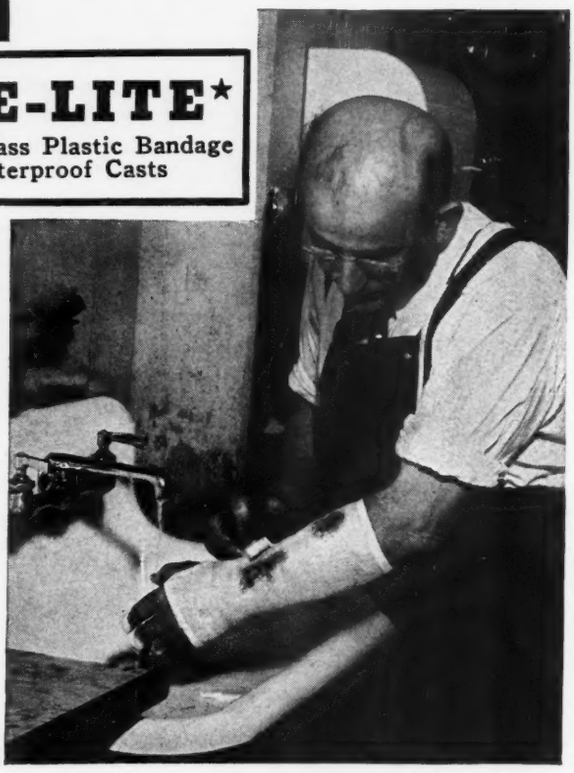

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Increasing attention has been focused in recent years upon the condition of Regional Ileitis. Ileotransverse colostomy with ileal exclusion has been advocated as the operation of choice—curative in many cases. On the following pages The Armour Laboratories presents a step by step picturization of this procedure. This constitutes the second in Armour's surgical illustration series by the noted medical artist, Dr. Frank Netter.

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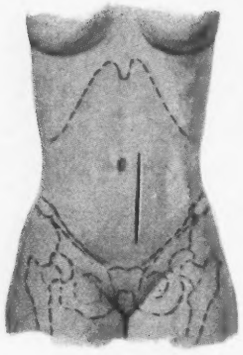
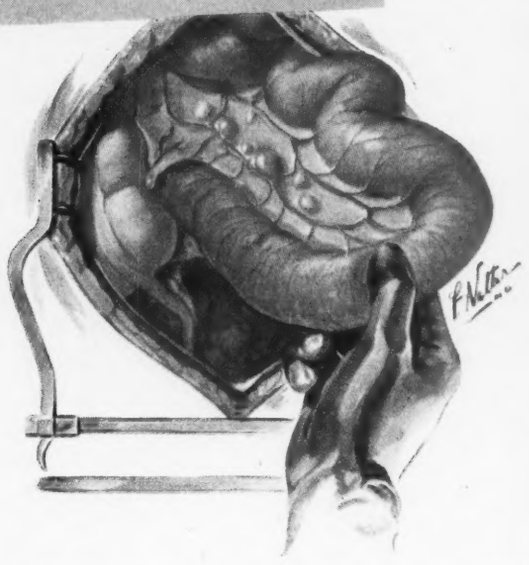
Surgical Treatment of Regional Ileitis

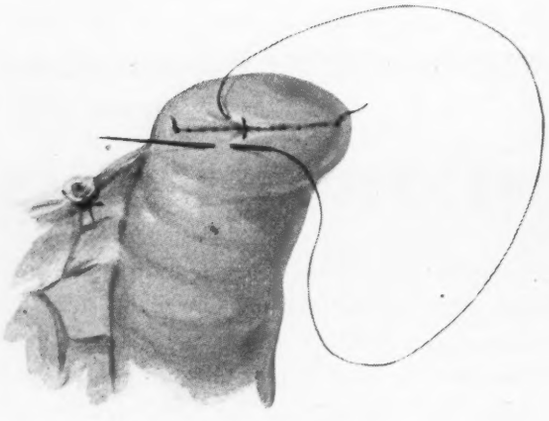
OPERATION: ILEO-TRANSVERSE COLOSTOMY WITH ILEAL EXCLUSION



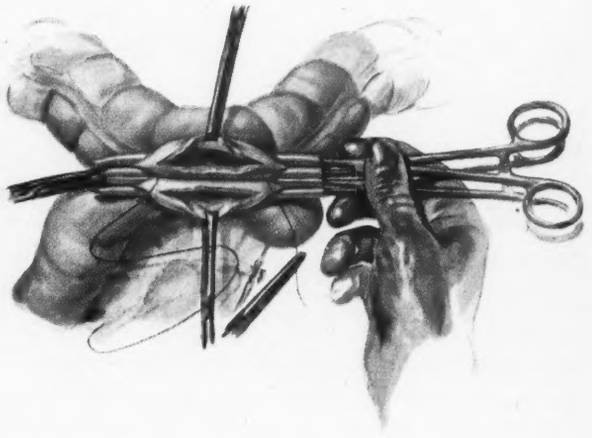
I: Adequate Left Rectus Muscle Splitting Incision
Note: a) Incision away from disease.
b) In case subsequent resection necessary—right side remains free.



II: Disease localized to terminal ileum is a chronic hypertrophic, stenosing granulomatous lesion. Rest of small bowel has been examined and is free of "skip" lesions.

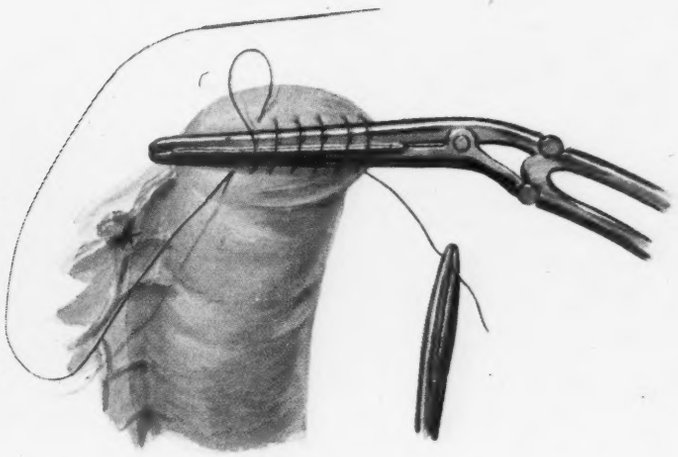


V: Closure continued, showing second layer of sutures.

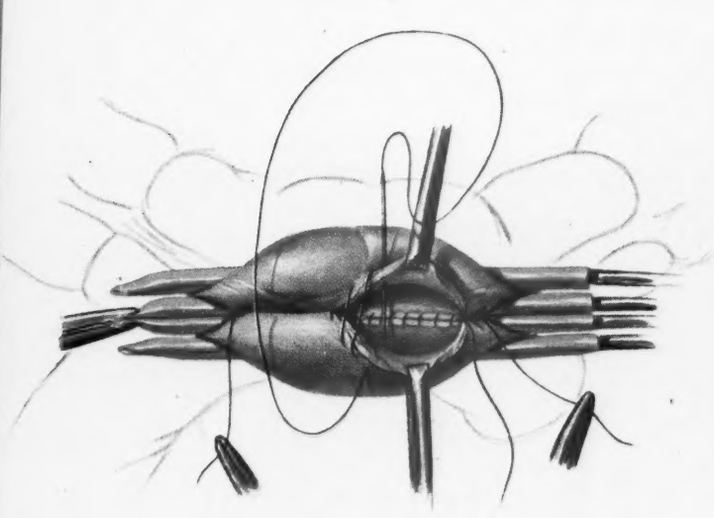


VI: Iso-peristaltic ileo-transverse colostomy over rubber-covered clamps. First layer (peritoneal sutures) placed.

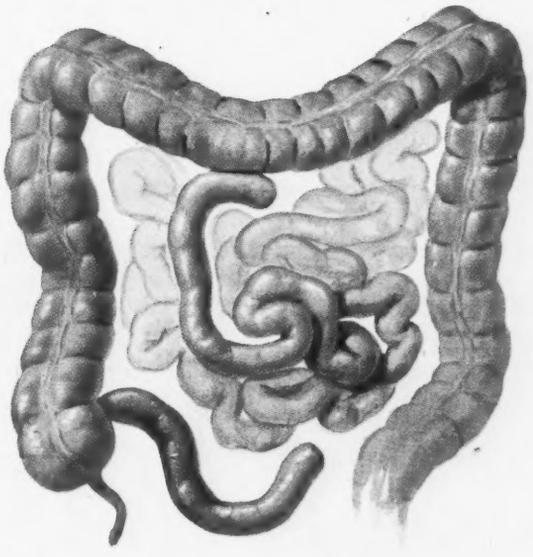
III: Ileum and mesentery divided between Payr clamps about 8 to 12 inches above disease.



IV: Closure of both ends over Payr clamps—"Parker-Kerr Technique."



VII: Inner suture being placed.



VIII: Diagram of completed operation. Note ileal exclusion.

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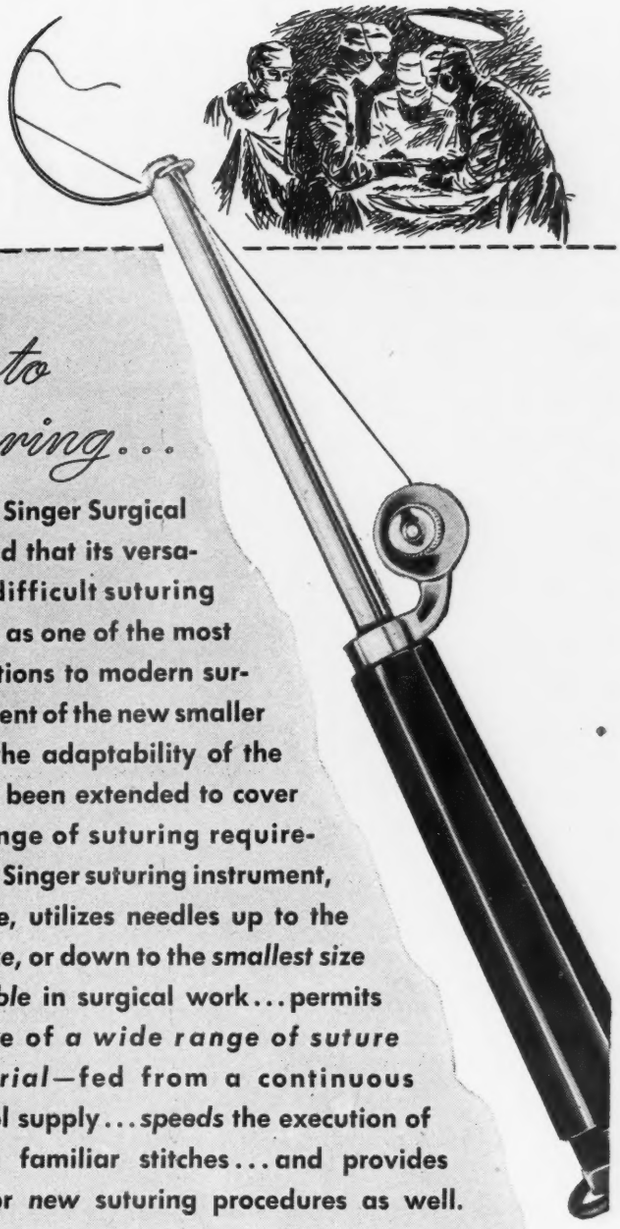

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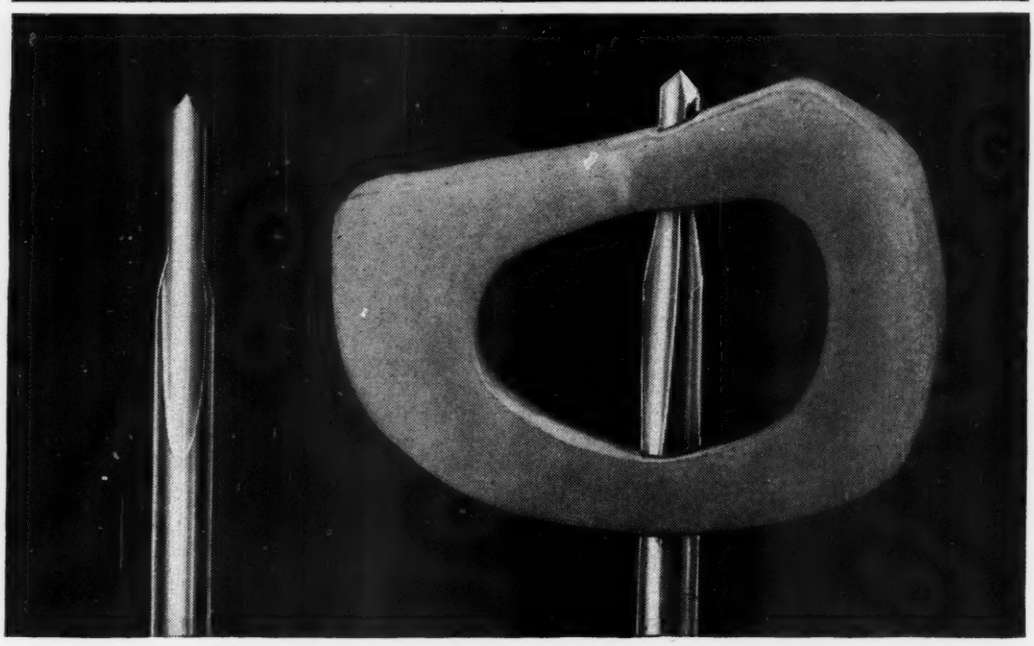

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*McDonald, R. H.: (Headaches of renal origin): M. Clin. N. Am. 24:365 (March), 1940.

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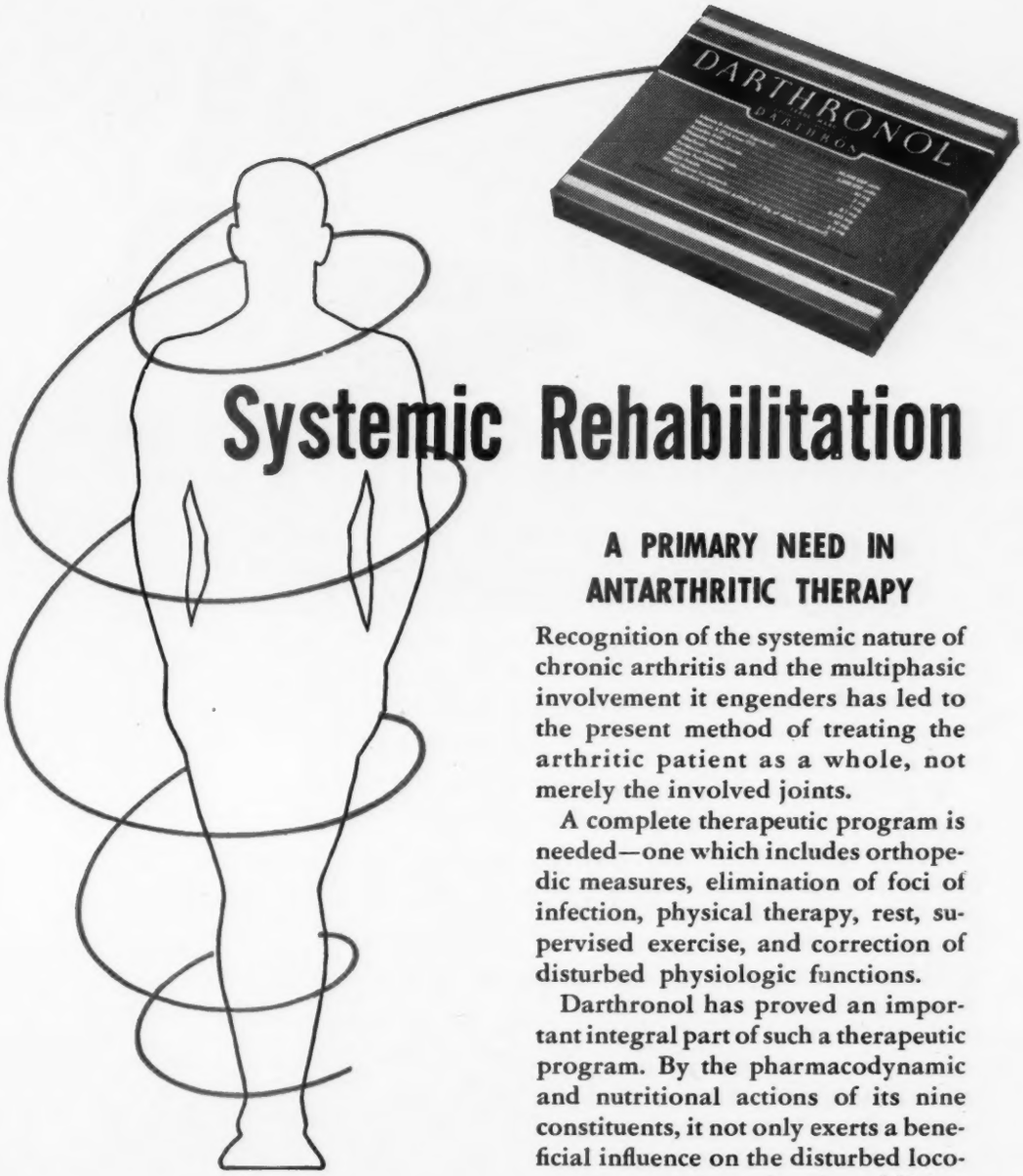

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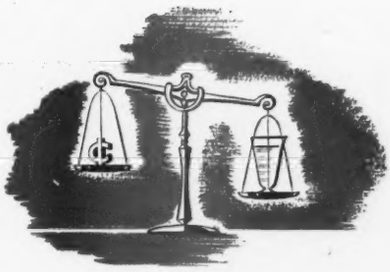

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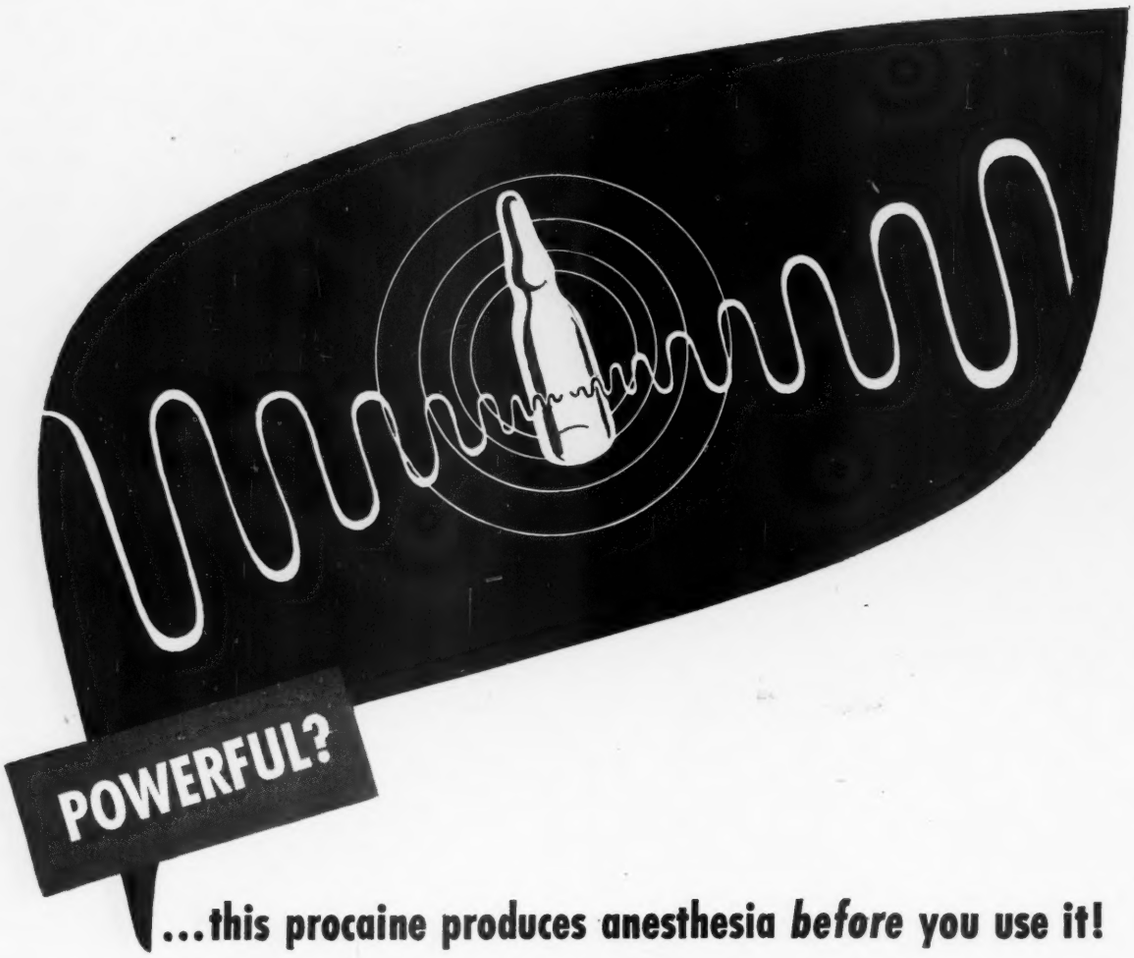

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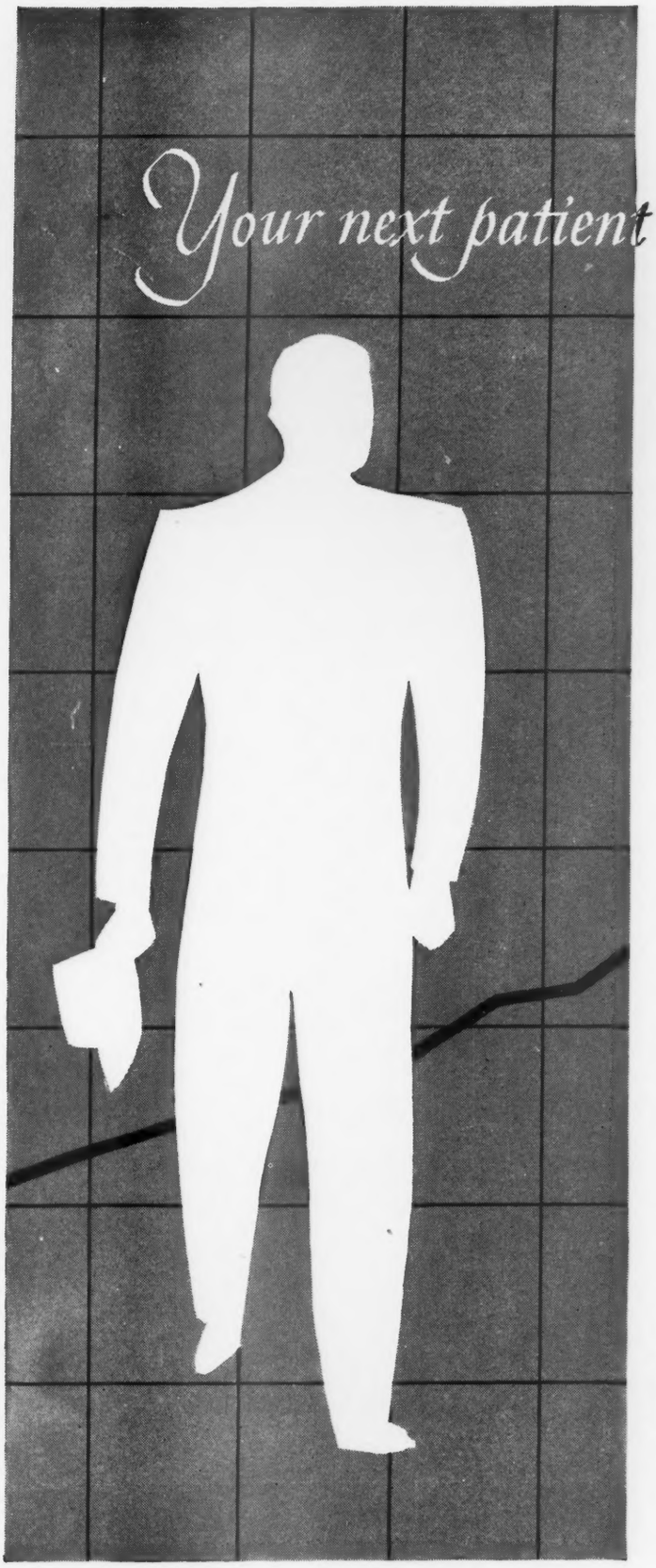

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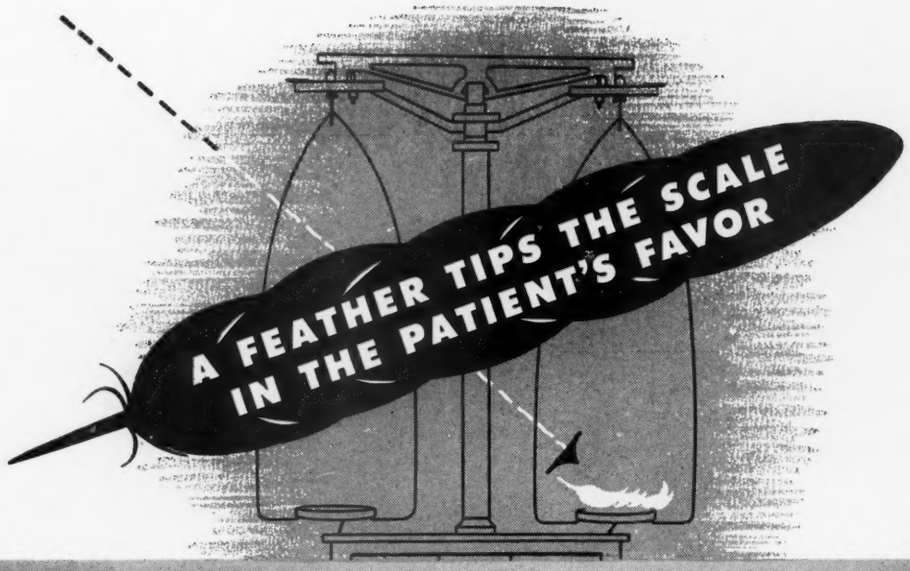

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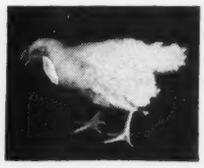

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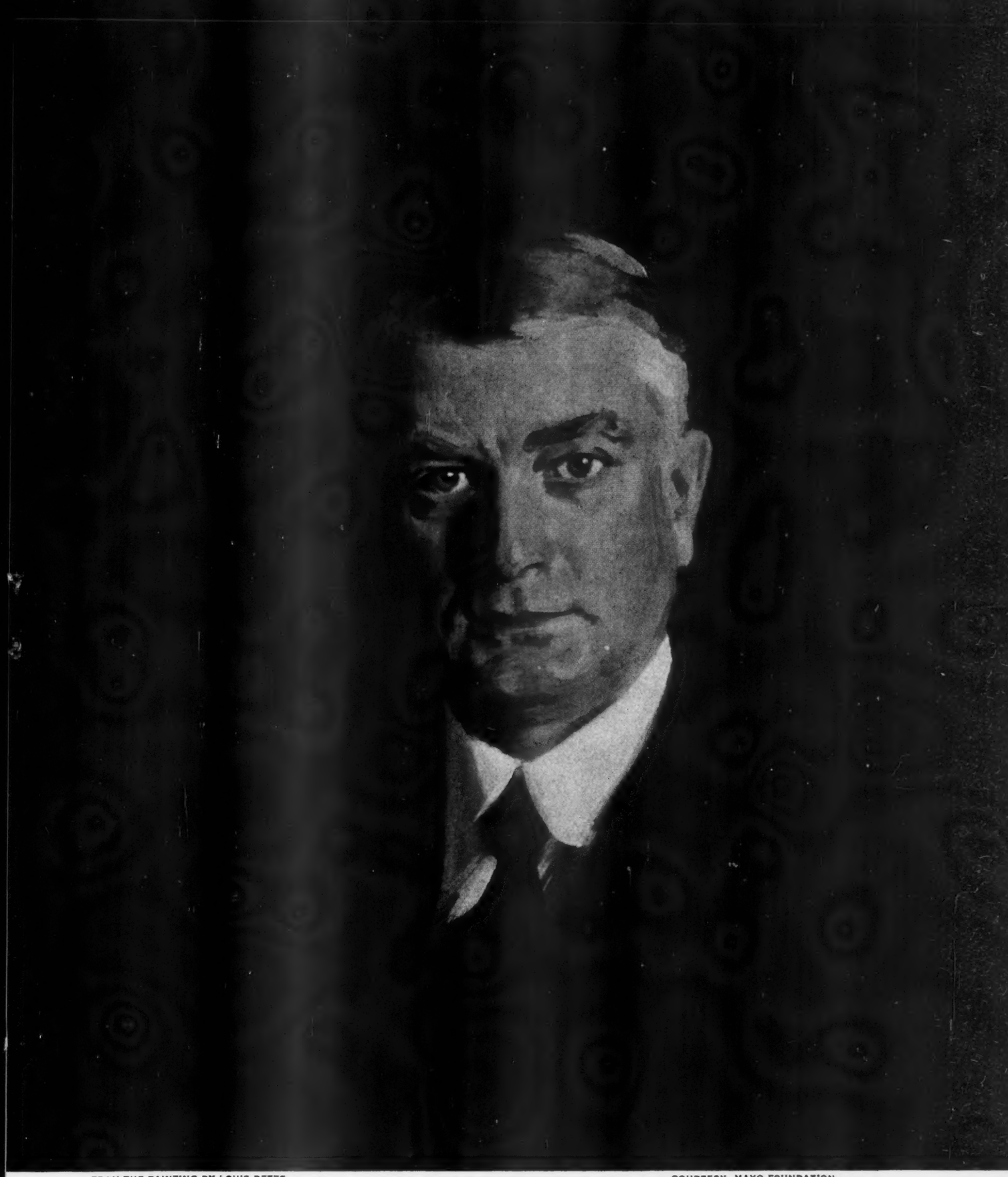

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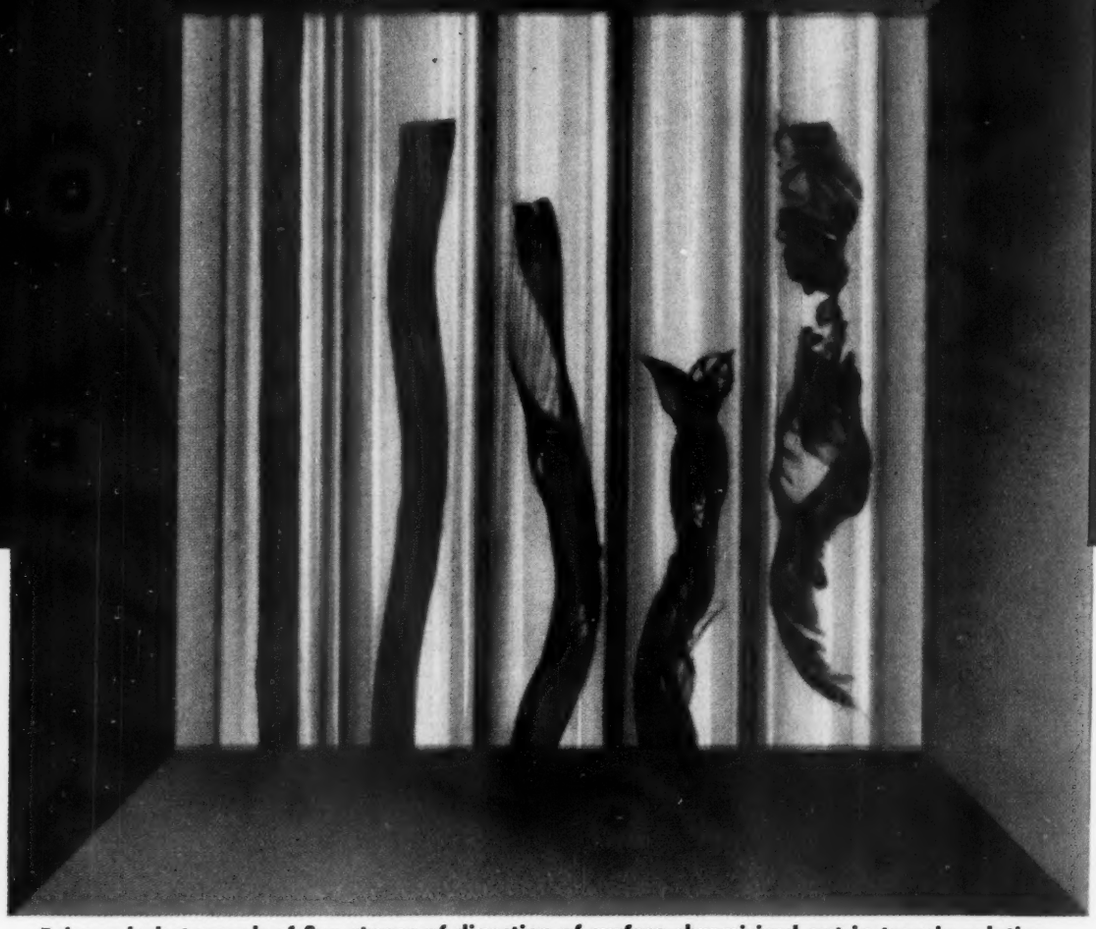

Enlarged photograph of five stages of digestion of surface-chromicized gut in trypsin solution.

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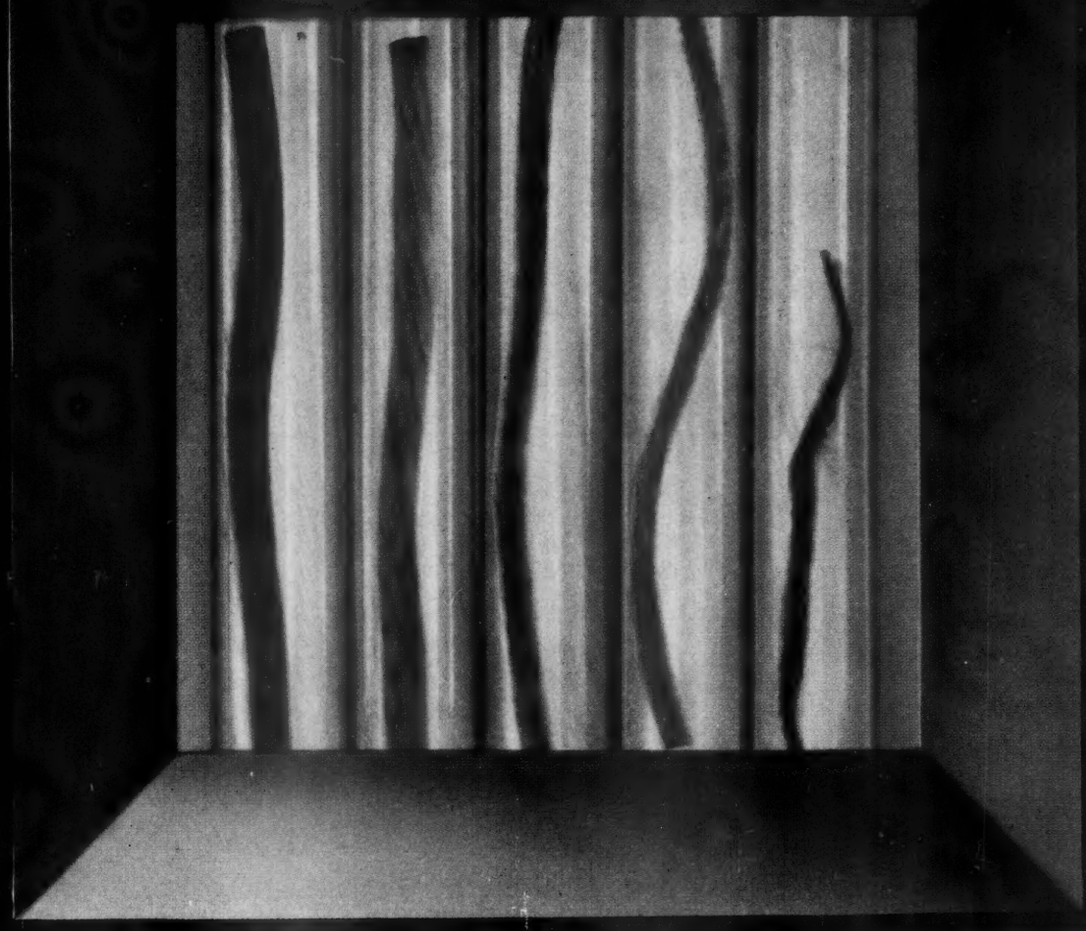

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Editorial

THE DIAGNOSTIC PROBLEM OF MALIGNANT BONE TUMORS

THE most valuable response of the human body to pathological conditions is that of pain. Persistent bone pain should always be given careful attention. A visit to the physician may be made because of a recent injury and may lead to the discovery of a bone tumor. A history of malaise, fever, local heat or swelling, suggestive of an infectious process, may also lead to the discovery of a bone tumor.

Patients must be constantly warned against waiting for pain to occur before consulting the physician for any suspicious lesion in the soft tissues, such as a lump in the breast. In many soft tissue malignancies, pain is not an early symptom, however.

Persistent bone ache early in the course of a bone tumor is not unusual. This is probably produced by the pressure of the growing tumor on the rigid non-expanding walls of bone. This pain may at times be described as drawing in character, or boring or rheumatic. While the pain may either develop gradually or come on suddenly or be intermittent, it is a symptom of the utmost importance and always warrants a careful search to discover the cause that produces it.

The history of the onset and course of the condition should be logically arranged and carefully evaluated. In bone tumors the family history may be of considerable importance, for while the inheritance of tumors in man is not established, we do know that family susceptibility for malignant growths is frequently encountered. Whenever there is persistent bone pain over a few weeks, this should always be regarded as suspicious of some underlying bone disorder and studied accordingly. If we can discover the time when the region affected last felt perfectly well, we may be able to determine roughly the time of the onset of a suspected bone tumor.

In the examination the general appearance of the patient may at times be suggestive of malignancy. The age of the patient may also be of definite value in the differential diagnosis. The examination must consist of a complete general study of the patient while investigating the local area. In the case of a suspected metastatic lesion, other systems of the body may need to be studied to determine the primary lesion. The veins in the skin over the involved region may be large and prominent and the skin have a peculiar cyanotic color. Investigation of the site, size, appearance, shape and feel of the tumor mass should be made. While malignant bone tumors may occur in any part of the skeleton, there are certain sites of predilec-

tion for certain types of bone tumors as Geschickter and Copeland have so graphically pointed out in their book.

The laboratory studies should include a Wassermann or similar test, complete blood and urine examinations, and frequently blood chemistry determinations of phosphorus, calcium, phosphotase and proteins. The roentgenogram, however, is of special aid in making the diagnosis. In the past we may have leaned too heavily upon the appearance of the roentgenogram and while this valuable ally undoubtedly furnishes more data than any other one diagnostic aid, the roentgenogram must not be relied upon to the exclusion of everything else. It is unnecessary to stress the need for having as good a film as can possibly be obtained, not only of the local lesion but at times of the opposite region as well. A roentgenogram of the chest is necessary in all suspected cases of malignant bone tumors and at times a complete bone survey may be advisable. If, however, our diagnosis rests wholly on satisfactory roentgenograms, errors in diagnosis will result.

In considering the pathological report, the value and advisability of either a punch or exploratory biopsy arises. To avoid open surgery in suspected lesions, punch biopsy has been found useful, particularly in the soft tissue lesions. The method has obvious limitations in bone lesions. A negative punch biopsy is not conclusive, although a positive one may be very helpful. While the danger of a biopsy by incision and removal of sufficient tissue at times may be very real, whenever a bone lesion is surgically accessible and the diagnosis doubtful, there should be no hesitancy in recommending it. We would like to suggest in this connection that a great deal of benefit can be obtained by having the radiologist and the pathologist in the operating room when the surgeon removes tissue for diagnostic purposes. The area for microscopic section should be jointly decided upon by these three, rather than hoping that the pathologist will intuitively section the desired area.

In tumors of the osseous system as well as malignancies in other parts of the body, early diagnosis and early treatment are always most important and, unfortunately, most difficult to obtain. In tumors of bone the old proverb, "The more certain the diagnosis, the less certain the probability of cure," is strikingly applicable.

The necessity for having a uniform classification for bone tumors is obvious, but we should like to stress the importance of using the grouping prepared by the Committee on Bone Sarcoma of the American College of Surgeons. This classification has been revised at intervals and the careful adherence to this plan has resulted in much valuable statistical information being collected.

With the array of data obtained as has been described, one might assume that a correct diagnosis can be made in all cases of suspected malignant bone tumor. Occasionally there is one other factor which enters into the picture and this is the subsequent course of the patient. Very rarely, but occasionally, even after a careful pathological report, the original diagnosis and prognosis may have to be changed as one observes the course of the patient. Therefore, the passage of time is an important factor in proving or disproving our diagnosis.

The great majority of bone tumors can be diagnosed correctly if we rigidly insist upon a careful history, a complete physical and laboratory examination, adequate *x*-rays, and a reliable pathological report.

In certain large medical centers, bone tumor clinics have been established and these daily illustrate the value and need of complete cooperation and coordination of all modern facilities for studying and investigating the special problem of bone tumor pathology.

Paul C. Colonna, M.D.

Original Articles

THE PROBLEM OF DELAYED UNION AND NON-UNION OF FRACTURES

CAPT. H. C. FETT, LT. COMDR. R. F. FOOTE AND LT. COMDR. M. A. L. STEVENS
MEDICAL CORPS, UNITED STATES NAVAL RESERVE

AT this activity the problem of delayed and non-union is a frequent one as is evidenced by the frequent bone graft operations which appear on the operative schedule. Each week at least two bone grafts are applied for the above conditions so that over a period of a year sufficient material has accumulated to warrant the publication of the methods employed, complications and end results.

The problem of delayed union and non-union of fractures following injuries and wounds in the military service is a great one and undoubtedly stands high on the list as the cause of many sick days lost. The problem is not new and while many studies have been made in bone and joint surgery the end results of treatment in these cases often leaves much to be desired.

Fortunately most of the fractures that are seen in the military service heal without difficulty, but it is those that fail to unite which tax the ingenuity of the Naval Surgeon.

The marked comminution and compounding of bones of the extremities, with injury to blood and nerve supply and disruption of muscle pull are all factors that contribute to our problem of delayed and non-union of fractures. Infection undoubtedly contributes a major factor in the problem. Accordingly, our problem is to control and eliminate the infection, restore the bone loss, stimulate osteogenesis, correct muscle imbalance and nerve disruption, and supply rigid fixation until such a time that satisfactory union is established.

DELAYED UNION

Union is regarded as delayed when healing does not progress at the anticipated rate for the type and location of the fracture. As long as there is evidence either clinically or roentgenographically that the process of repair has not ceased, calcification of the fracture should be regarded as delayed.

The treatment of delayed union is largely conservative and consists principally of efficient fixation provided we can be sure that interposition of tissues between the fractured ends does not exist, and satisfactory reduction and good apposition of the fragments is present. Maintenance of muscle tone by planned exercise and physiotherapy are also useful adjuncts, as they improve the local physical tone of the tissues.

If after a reasonable period of time and observation of the above mentioned facts we find that little evidence of callus formation and union is present, we are then justified in undertaking more extensive and radical procedures rather than risk further delay in convalescence. Under these circumstances we have resorted to the operation of drilling of the fragments about the site of the fracture.

Drilling is not a new procedure but was first described in detail by Daniel Brainard in 1854.[1] The procedure is not difficult and consists principally of drilling

six to twenty holes obliquely across and through the fracture site. By this means, osteogenesis may be stimulated through

FIG. 1. *X*-ray evidence of non-union. Cupping, thin cortex, widened medullary cavity; bone atrophy; bone sclerosis.

increased circulation to the fractured surfaces from the periphery of the bone. Following this procedure, the extremity is immobilized in plaster for a period of six weeks or as long as is necessary to secure union after which further treatment is carried out as planned for a fracture in which union is not delayed. Our results with this method have been most successful when used for fractures of the tibia, but the procedure may be used with success in treatment of delayed union of any of the other long bones.

NON-UNION

When a fracture in a bone fails to unite, non-union is said to exist. For years, six months has been accepted as a sufficiently long period to wait for union to occur.[2] However, it is often possible to determine by *x*-rays, long before this time, whether or not union will take place. This interval varies, as union has often occurred after a longer period, especially following some complication such as infection.

The end result of non-union may be one of three types:[3] (1) Pseudoarthrosis, (2) fibrous union with osteoporosis of the fragments, and (3) fibrous union with atrophy of tissue.

1. *Pseudoarthrosis* is characterized by the formation of a shallow cup usually on the proximal fragment which apparently is the result of greater functional stimulation of this fragment. Callus forms on each fragment rather than across the fracture line and obliterates the medullary canal. The bone appears sclerosed and is of inferior quality closely resembling scar tissue.

2. *Fibrous union* with osteoporosis is characterized by rapid, irregular absorption of lime salts as is evidenced by mottling of the fragments. The process extends for a considerable distance to each side of the fracture line and while the cause of this phenomenon is not definitely known it has been suggested that the vasomotor and sympathetic nervous systems may play a part in its development.

3. *Bone atrophy* of disuse is usually always present and progresses with the passage of time. It is related to the loss of functional stimulation of cellular activity by disuse. The bone appears pale and its transverse diameter appears to be decreased. At operation it is not unusual to find that the bone cortex is thinner while its marrow appears to be enlarged and is filled by an increased amount of fat. Decreased vascularity is also a common finding.

Having considered the types of non-union as revealed by *x*-ray (Fig. 1), it might be well to consider the other factors that may play a part in the development of our problem.

1. *Constitutional Factors.* Undoubtedly systemic disease may play a large part in the development of this problem. However, the serviceman is usually in the best of health prior to injury, as he is young and well nourished. Although his injury is severe "he still has enough fight left in him to bounce back." If another disease is present, we treat it but we do not believe

this factor is prominent in our young serviceman.

Vitamins, calcium and phosphorous studies, blood proteins and endocrine factors must all be considered but we have not been able to demonstrate by available laboratory studies that these factors play an important rôle in our problem. In fact it has been most unusual for us to demonstrate any disturbance in the body chemistry.

2. *Inadequate nutrition* of the bone due to site of fracture and injury to the nutrient arterial system probably plays a large part in the development of the problem of non-union. Injury to the periosteum with its concurrent impairment of circulation to the part also adds to the problem. With loss of circulation or diminution thereof we may expect the process of healing to be retarded. This is well brought out in fractures through the neck of the femur. This contributes to the delay and non-union of fractures through this site.

3. *Nerve influence* on the site of fracture still is not clear. Muscatello and Damaschelli[5] found that after section of the peripheral nerves there was no disturbance in the formation of callus and consolidation and union occurred without delay.

The rôle of the sympathetic nervous system in non-union is likewise not clear. Felix[6] in his experiments on dogs, resected the ganglion, and after section of the shafts of the tibia and ulna, more than half of the cases showed acceleration of union on the sympathectomized side, due to resulting hyperemia. Defect pseudoarthrosis developed only when the periostium was removed.

While much work is yet to be done before the exact rôle of nerve influence can be definitely worked out, we believe that additional nerve injury in fractures contributes to our problem as it delays the return of function to the affected part and contributes to muscle imbalance.

4. *Infection* continues to be a "bugaboo" to the surgeon. Until it can be controlled and eradicated our final treatment of fractures is often delayed. Its concomitant destruction of bone and resulting bone sclerosis is deleterious as far as bone repair is concerned, and often the bone at the fracture site after infection is found to be hard, dense, and deficient in circulation and osteogenetic powers.

5. *Interposition of tissues* continues to remain high on the list of causes of non-union.[7] While some fractures may go on to complete union despite the interposition of soft tissue, one cannot help but notice at operation how often muscle and periostium is found interposed between the fractured ends. Undoubtedly this tissue contributes to delayed union and non-union, and upon removal and freshening of the ends of the fractured fragments, union may occur.

6. *Insufficient immobilization* practiced by the impatient surgeon is a frequent cause of delayed union and non-union. As soon as a fracture is reduced and the bone ends are placed in apposition, rigid fixation and immobilization must be maintained if healing of the fracture is to progress satisfactorily.[8]

While plaster remains the best method of immobilization in general use, we must not forget that a cast that appears snug and comfortable after application may become loose after swelling has subsided and muscle atrophy of disuse has developed. When this occurs, a new cast must be applied if adequate immobilization is to be continued. A loose cast with motion at the fracture site in early fractures will contribute toward disruption of the process of repair. The young capillaries are ruptured and the cellular arrangement of new callus is disturbed. The forces that produce pseudoarthrosis are shear, and friction, and if this is to be avoided strictest immobilization must be maintained. The joints above and below the fracture site must be immobilized. Once healthy and well nourished callus is formed, motion is stimulating.[9] Motion earlier than this will delay the process of healing and disturb the bony contact at the fracture site, all

of which tends to prolong the process of healing.

The fracture must be reduced early and immobilization must be satisfactory and prolonged until such a time that *x*-rays reveal sufficient callus.

While the causes of non-union may be many, the vast majority are due to imperfect anatomical reduction and to lack of adequate immobilization.[9]

OPERATIVE TREATMENT OF UNUNITED FRACTURES

Having considered the many factors that may contribute to the development of non-union we now turn to the various operative procedures at our disposal.

When a fracture fails to unite after a sufficient interval of time, operative interference is usually indicated.[10] The object is to provide extra bone for the bridging of gaps, filling of defects, and stimulation of osteogenesis, after which immobilization in satisfactory position is to be continued until union occurs. The sooner the condition is recognized and treated the better the chance of success and the shorter will be the patient's convalescence. Having obtained clinical and *x*-ray evidence of non-union, the case must be evaluated and the predisposing causes if known eliminated. All medical and surgical aides at our disposal must be brought into play as the patient must be in the best physical condition possible prior to operation. Blood, iron and vitamins are used freely and all contributing factors to non-union are eliminated as far as possible.

The accepted treatment of non-union is the transplantation of an autogeneous bone graft, and in the treatment of our patients with non-union we have used autogeneous bone grafts whenever possible.

The use of bone grafts is not new. Jentzer[11] mentions the use of bone grafts in India as early as 500 B.C.; however, it was not until the latter part of the last century that the use of bone grafts came into its own. The work of Albee[12,13,14] during the past thirty-five years has done much to stimulate interest in bone grafts and standardize their use in this country.

Experience has clearly demonstrated the inefficacy of certain types of grafts and the value and indications of others. Bone grafts are used in ununited fractures chiefly to fill defects, aid in fixation, aid in re-establishing circulation and to promote osteogenesis. Of the many and varied types of grafts considered in the literature we have limited our use to one or more of the following grafts. (1) Inlay graft, (2) onlay graft, (3) osteoperiosteal grafts (wafer), (4) intramedullary grafts, and (5) primary bone grafts.

In obtaining our autogeneous bone grafts we have usually selected the medial aspect of the tibia for the donor site. The graft is cut with a bone saw and is ½ to ¾ inch across and is six to eight inches long or as long as is required and includes all three types of bone, namely, periosteum, cortex and endosteum. Prior to cutting our graft the fracture site is exposed and freshened by means of a motor-driven saw. The marrow cavity at the fracture site is usually found to be closed off by avascular sclerotic bone, and by curettage or drilling the marrow cavity can be opened to allow better vascularization which will enhance the process of union. Having completed the freshening of our fracture site we now obtain satisfactory alignment and apposition under direct vision. Satisfactory reduction is maintained by bone clamps and the desired type of graft is cut and placed over the fracture site. Two or more drill holes are placed through each end of the graft and fractured segments and then fixed by vitallium screws. The wound is closed in an accepted manner and plaster immobilization is applied and maintained until clinical and *x*-ray evidence of union has occurred.

The *inlay bone graft* was first used by Albee. The inlay and sliding inlay bone graft has been found in our experience to be more adaptable to use in fractures of the tibia. Having refreshened the fracture site and obtained satisfactory reduction

Fig. 2. Fig. 3.

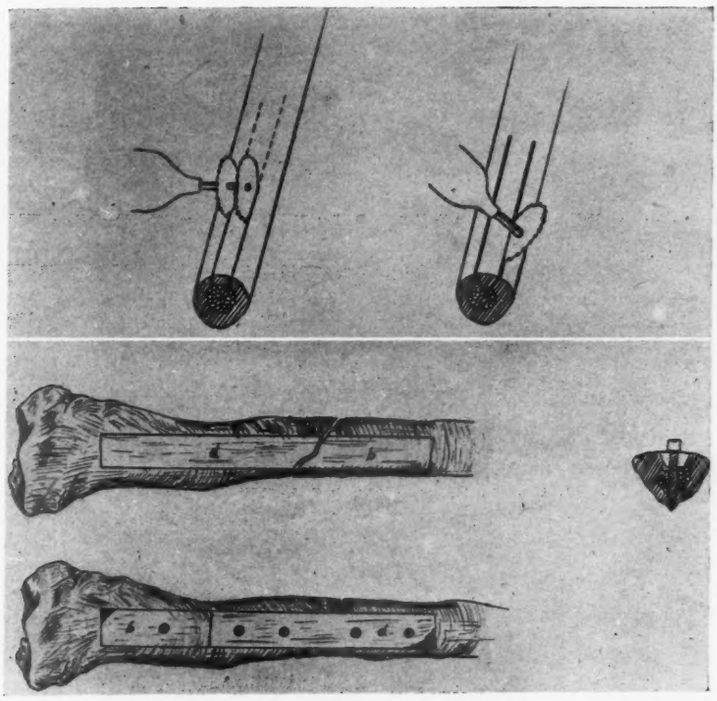

Fig. 4.

Fig. 2. Double blade saw.
Fig. 3. Single blade saw.
Fig. 4. Sliding bone graft.

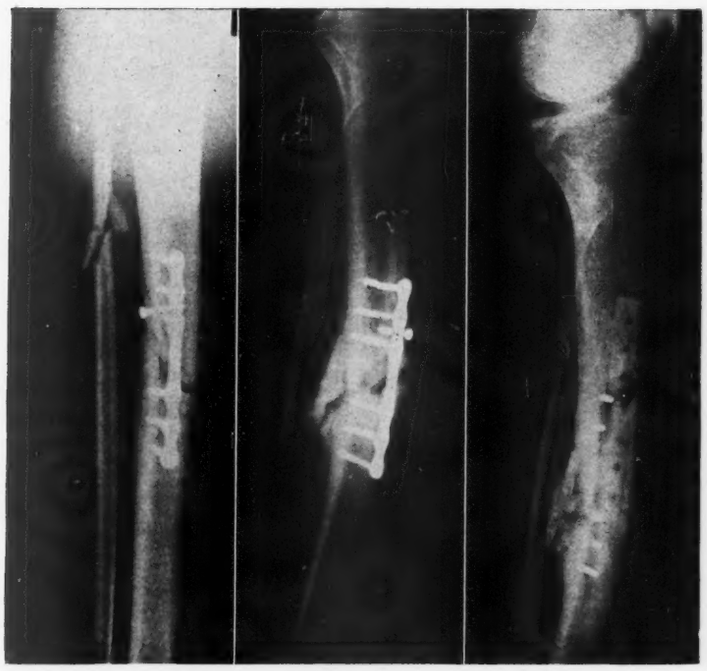

Fig. 5. Fig. 6. Fig. 7.

Fig. 5. Case 1. Post-reduction plate.
Fig. 6. Case 1. Four months after plating. Clinically non-union; pain and motion at fracture site; patient has fractured five out of seven screws.
Fig. 7. Case 1. Eight weeks after bone graft; union by *x*-ray and clinically.

we cut a graft that is usually six inches long and one-half inch wide and extends from healthy bone down to and across the line of fracture. The graft may be cut with a parallel blade saw or with a single blade saw. If the double blade saw is used (Fig. 2), the graft may often be smaller than the space from which it was cut and as a result it may sink into the medullary cavity. If the graft is cut with a single blade saw (Fig. 3) and the saw is directed in an oblique direction toward the medullary cavity, the sliding graft will fit more snugly in its new position and give a certain amount of fixation. Having cut the graft it is now reversed and set in its trough. The longer portion bridges the fracture site. (Fig. 4.) The shorter fragment is fitted into the remaining space. The graft is held snugly by at least two vitallium Phillips head screws to each fracture fragment. The periosteum is closed as are the overlying tissues and the limb is immobilized by the application of a high thigh plaster case. Three cases are presented to illustrate this type of bone graft.

Fig. 8. Fig. 9. Fig. 10.

Fig. 8. Case 11. Oblique fracture of right tibia and fibula August 1, 1944, in war zone.

Fig. 9. Case 11. Open reduction; four-hole plate inserted five weeks after plating overseas.

Fig. 10. Case 11. Seven weeks after tibial sliding graft; six months after original fracture. Early evidence of union of graft; callus across fracture site.

CASE REPORTS

Case 1. The patient, age eighteen, while playing baseball, was knocked down by another player. As a result, he sustained a simple comminuted fracture of the left tibia and fibula through the middle third. On August 18, 1944, an open reduction was done and a six-hole vitallium plate was applied. One additional transfixation screw was used to hold the largest comminuted fragment in place. (Fig. 5.) A high thigh plaster cast was applied. Six weeks later considerable callus formation was present

and limited weight bearing was started. Four months after fracture (Fig. 6), the patient had marked callus formation. Five out of seven screws were broken and there was marked anterior bulging of callus. Pain and motion at the fracture site were present. Open operation revealed fibrous union and the excess callus was removed, bone ends freshened and a sliding bone graft inserted. A high thigh plaster cast was applied. Eight weeks after the bone graft was inserted (Fig. 7) union was present clinically and by *x*-ray.

Case II. This patient, age twenty, was knocked down and trampled during an air raid and sustained a simple spiral type fracture at the junction of the middle and lower thirds of the right tibia and fibula. (Fig. 8.) Because of angulation, poor apposition and shortening, an open reduction was done and a four-hole vitallium plate was used to maintain reduction. (Fig. 9.) High thigh plaster was applied and the patient was evacuated to the mainland. Three months later the plaster cast was removed. Union appeared to be present clinically and the patient was started on physiotherapy and weight bearing. Six weeks after removal of the cast the patient complained of pain and motion at the fracture site. *X*-rays revealed evidence of non-union. Clinically non-union was present. Open operation revealed fibrous union. The fracture site was freshened and a sliding tibial bone graft was inserted after which a high thigh plaster cast was applied. Seven weeks later the cast was removed. The wound was well healed and clean. *X*-ray evidence of early union of bone graft and moderate callus production across fracture site was present. (Fig. 10.) A high thigh plaster cast was reapplied and will be maintained until there is *x*-ray and clinical evidence of solid union.

Case III. This patient, age twenty-six, sustained a compound transverse fracture of the right tibia at the junction of the lower and middle thirds on September 25, 1944, when struck by a falling steel plate. The wound was debrided, the fracture reduced and the leg incorporated in a high thigh plaster cast after which he was evacuated through various hospitals overseas and arrived on the mainland ten weeks later. *X*-rays revealed considerable angulation and little evidence of union. Clinically non-union was present fourteen weeks after injury. (Fig. 11.) The deformity was corrected and a sliding tibial bone graft was inserted. *X*-rays were taken four weeks after the sliding tibial bone graft was applied.

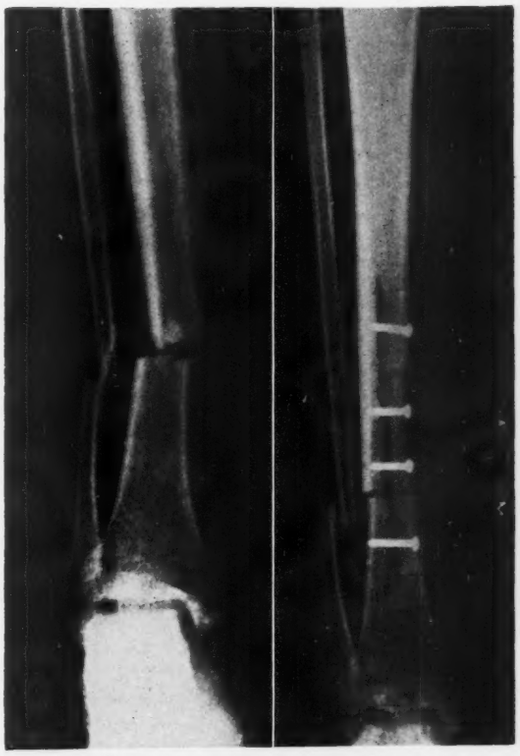

Fig. 11. Fig. 12.

Fig. 11. Case III. Fractured tibia and fibula fourteen weeks after injury; angulation, deformity and no evidence of union.

Fig. 12. Case III. Six weeks after sliding tibial bone graft. Position satisfactory; no evidence of union. Graft appears to be broken; *x*-ray film proves this to be untrue as trabeculae are visible across the apparent fracture of the graft.

The deformity was corrected six weeks after bone graft. (Fig. 12.) The position remains satisfactory but there is no evidence of union as yet.

The *onlay bone graft* was popularized by Campbell and Henderson. This type of graft has found its best use in treatment of fractures of the humerus, bones of the forearm and femur. It has the advantage in that a massive graft can be applied and the size is not limited by the size of the trough; in fact, a double onlay graft may be used when indicated.

Here again the fracture site is freshened as is the recipient site for the graft and in the meanwhile a second team cuts a

tibial bone graft of desired length and width. The spongiosa is paired down with the bone saw so that the graft presents a flat surface on its medullary side. The bone graft is then laid across the freshened fracture site which has been reduced and held in firm apposition under direct vision by means of bone clamps. Two or more drill holes are made in the graft and recipient site to each side of the fracture line. Vitallium Phillips head screws are inserted and reduction is maintained by a snug fitting onlay graft. The spongiosa chips are then laid about the fracture line to fill in any defect that may exist. (Fig. 13.)

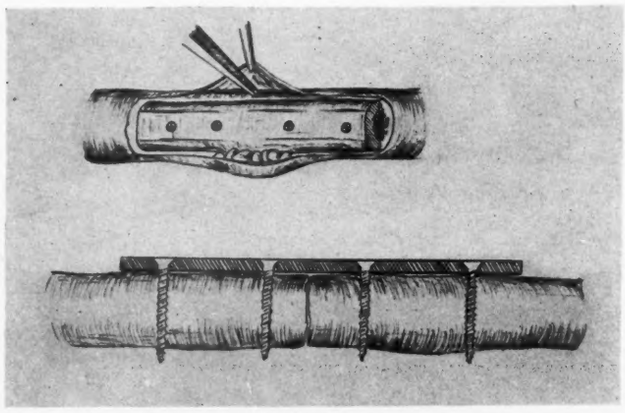

Fig. 13. Onlay bone graft.

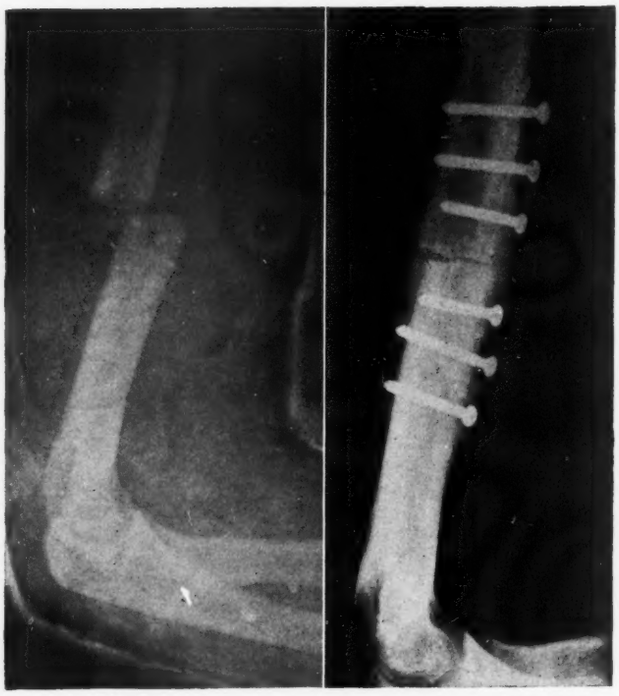

Fig. 14. Fig. 15.

Fig. 14. Case iv. Fracture of humerus, August 7, 1944. Treated by hanging plaster method for three months.
Fig. 15. Case iv. Eleven weeks after onlay bone graft; union clinically and by *x*-ray.

We have used massive onlay tibial grafts on some of our patients with non-union of fractures of the femur. However, unless satisfactory immobilization is maintained over a prolonged period, the risk of

fracturing the graft is great. To help overcome this possibility we have often used a vitallium plate in conjunction with the bone graft.

Case iv. On Aug. 7, 1944, while operating a boat hoist, the patient, aged twenty-two, slipped and fell against the bulkhead and sustained a simple transverse fracture of the right humerus at the junction of the lower and middle thirds. (Fig. 14.) He was treated by the hanging plaster cast method for three months. Because of lack of evidence of union, poor apposition of fragments and angulation, an onlay tibial bone graft operation was performed on October 16, 1944, and a plaster body cast with arm spica at 45 degrees was applied. Union was present clinically and by *x*-ray eleven weeks later. (Fig. 15.)

Case v. On October 7, 1943, this patient, age twenty-three, fell from a truck and sustained a simple transverse fracture of the left humerus. He was treated successfully by the hanging plaster cast method. On January 25, 1944, he slipped and fell and refractured his left humerus through the old fracture site. (Fig. 16.) On February 5, 1944, an onlay tibial bone graft operation was performed. Union progressed satisfactorily thereafter and on September 11, 1944, union was firmly established clinically and by *x*-ray. Muscle rehabilitation had almost completely restored function. (Fig. 17.)

Case vi. This patient, age twenty-three, sustained a simple, comminuted, transverse fracture of the upper one-third of the right femur, when his ship struck a mine off the coast of Normandy. He was thrown into the air and then fell through a hatch and landed two decks below. He was treated by skeletal traction and then incorporated in a plaster spica and evacuated to the mainland. Three and one-half months after injury, marked medial angulation and considerable callus formation was present. (Fig. 18.) Sixteen weeks after injury an open operation was performed, angulation corrected and a large tibial onlay graft applied and held in place by seven screws. A body cast with a right leg spica was applied. Sixteen weeks after the bone graft operation, union was present clinically and by *x*-ray. (Fig. 19.)

Case vii. This patient, age twenty-one, sustained a compound, comminuted subtrochanteric fracture of his right femur when his ship was torpedoed on August 5, 1944. He was treated by skeletal traction and then placed in a double hip spica and evacuated to the mainland. Examination seven weeks after injury revealed angulation, poor apposition and minimal callus. (Fig. 20.) Eleven weeks after injury, open reduction with application of tibial onlay graft and a four-hole vitallium plate and screws was performed after which a body cast with a right leg spica was applied. Sixteen weeks after the bone graft operation, union appeared to be present clinically and was substantiated by *x*-ray. (Fig. 21.)

Fig. 16. Fig. 17.

Fig. 16. Case v. Treated successfully by hanging plaster method; three and one-half months later; refracture through fracture site.

Fig. 17. Case v. Seven months after onlay tibial bone graft; union clinically; *x*-ray film demonstrates considerably more repair than is apparent in this photograph.

Osteoperiosteal Bone Grafts (Wafer Graft). This resembles the onlay graft but is considerably thinner. We have referred to them as "wafer grafts" and have used them successfully in cases of non-union of fractures of bones of the forearm. They contain periosteum, cambrium layer and some cortical substance and are prepared in the same way that the onlay graft is except that spongiosa as well as part of the

cortex is removed and as a result we have thin cortical graft which is applied across the previously prepared fracture site and held in place by four screws or wires. Our osteoperiosteal or "wafer" grafts are a little thicker than those described by Delangeniere.[15] We cut our graft in the same way that we cut an inlay graft after which we pare the graft down with the bone saw. The resulting graft is about one-half the thickness of the cortex of the tibia. A certain amount of care must be used in applying the graft and drilling the holes in order that the graft is not fractured.

Fig. 18. F.g. 19.

Fig. 18. Case vi. Fourteen weeks after injury; angulation, poor apposition and minimal callus.

Fig. 19. Case vi. Sixteen weeks after bone graft operation; union clinically and by *x*-ray.

Case viii. On January 10, 1944, this patient, age twenty-eight, sustained a simple transverse fracture through the middle third of the right radius and ulna (Fig. 22) when he bailed out of his plane and was struck by the tail fin. The fractures were reduced and the forearm and arm were immobilized in plaster. Angulation and non-union developed and on June 14, 1944, two "wafer grafts" were applied across each fracture site and were held in place by wires at each end of each graft. A plaster cast was applied from axilla to metacarpal heads with the forearm in midposition between pronation and supination and the elbow at a right angle. (Fig. 23.) Union was firm fourteen weeks later. Follow-up six months after the bone graft operation revealed full return of function. (Fig. 24.)

Case ix. This patient, age twenty-seven, slipped and fell thirty feet and landed on his left forearm and sustained simple fractures of ulna and radius at the junction of the upper and middle third. (Fig. 25.) An intramedullary Kirschner wire was inserted in the ulna and the malposition was corrected. (Fig. 26.) A plaster cast was applied from axilla to metacarpal necks with the hand supinated. The position of the radius was satisfactory. Five months later the radius was united but the ulna showed

no evidence of union. An open operation was performed and an onlay tibial (wafer graft) was applied and secured with four vitallium screws after which the extremity was immobilized in plaster. Ten weeks later (Fig. 27) union was present clinically and by *x*-ray and the patient was started on muscle rehabilitation.

INTRAMEDULLARY BONE GRAFTS

Intramedullary bone grafts have been used with variable results. Most authorities agree that the graft has little to offer for when the bone peg is cut and inserted into the medullary canal and across the fracture site, it embarrasses further an already depleted circulation to the bone fragments. While we do not advocate the general use of this graft when more reliable procedures are available, we do think that there are a few instances when the graft may be used to fill defects and realign separated fragments in the small bones such as the metacarpals and metatarsals. The use of a larger graft presents difficulties in these areas due to irregular and painful protrusions particularly when used close to a weight bearing surface.

Case x. This patient, age forty-two, sustained multiple severe injuries and a compound fracture of the first left metatarsal when his ship was torpedoed on September 11, 1943. He was treated by plaster immobilization and non-union developed. (Fig. 28.) On April 5, 1944, the fracture site was prepared and an intramedullary tibial bone peg was inserted. Position was satisfactory thereafter and union occurred four and one-half months later. (Fig. 29.)

Case xi. This patient, age twenty-two, received a gunshot wound of the right foot during the invasion of Saipan. A compound comminuted fracture through the shaft of the third right metatarsal was sustained. Débridement and plaster immobilization led to healing of the wound. Sixteen weeks later (Fig. 30) considerable comminution and non-union were present and an intramedullary tibial bone peg was inserted to fill the metatarsal defect and to aid in fixation after which a plaster boot was applied for immobilization. Twelve weeks later adequate fixation persisted and the defect had been filled. There was little evidence of union. Sixteen weeks later, minimal callus formation was present and there is early evidence of union. (Fig. 31.)

Fig. 20. Fig. 21.

Fig. 20. Case vii. Compound subtrochanteric fracture of femur; seven weeks after injury; angulation; poor apposition; minimal callus.

Fig. 21. Case vii. Sixteen weeks after onlay tibial bone graft; union clinically and by *x*-ray.

PRIMARY BONE GRAFTS

A primary bone graft is one that is used shortly after an injury is sustained. It has all the advantages of the other bone grafts plus the added factor that it is used early and long before non-union has occurred and therefore theoretically should be an added and early stimulus to union. Perhaps its greatest use will be in the early treatment of fractures by open reduction and fixation at the sites that are notorious for non-union. We have used a primary sliding inlay graft in one case of spiral oblique fracture of the tibia at the junction of the lower and middle thirds. Progress has been satisfactory thus far or six weeks after the operation was performed. Further

FIG. 22. FIG. 23. FIG. 24.

FIG. 22. Case VIII. Fracture of right radius and ulna January 10, 1944.
FIG. 23. Case VIII. Wafer grafts in place; angulation corrected.
FIG. 24. Case VIII. Six months after application of "wafer grafts"; union solid clinically and by *x*-ray; full return of function.

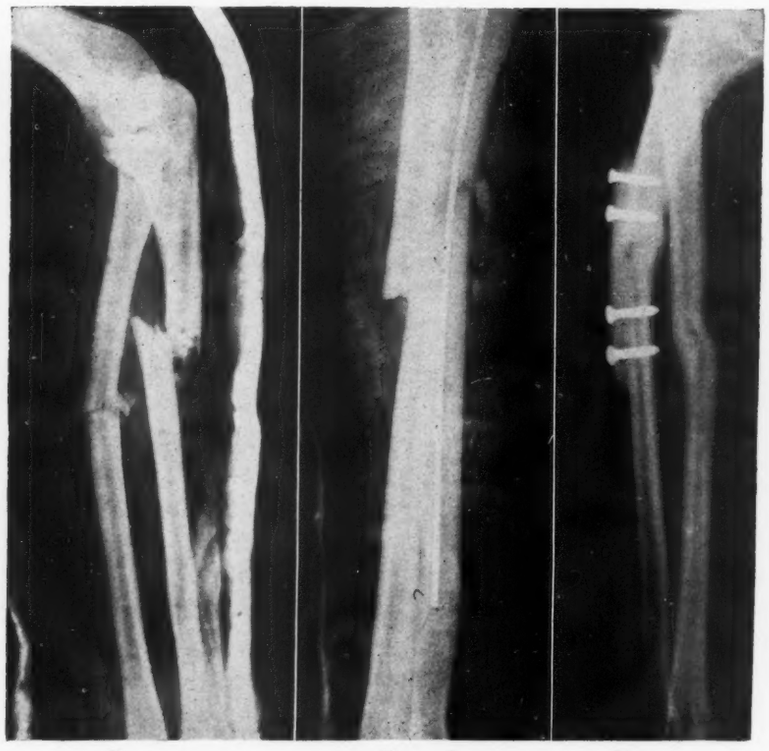

FIG. 25. FIG. 26. FIG. 27.

FIG. 25. Case IX. Fracture, simple, of left radius and ulna.
FIG. 26. Case IX. Fracture of left radius and ulna one month later; intramedullary wire to secure alignment of ulna.
FIG. 27. Case IX. Ten weeks after "wafer graft" to ulna; union clinically and by *x*-ray.

Fig. 28. Fig. 29.

Fig. 28. Case x. Non-union of first left metatarsal, seven months after injury.

Fig. 29. Case x. Union of fracture of first left metatarsal, eleven months after injury and four and one-half months after intramedullary bone graft.

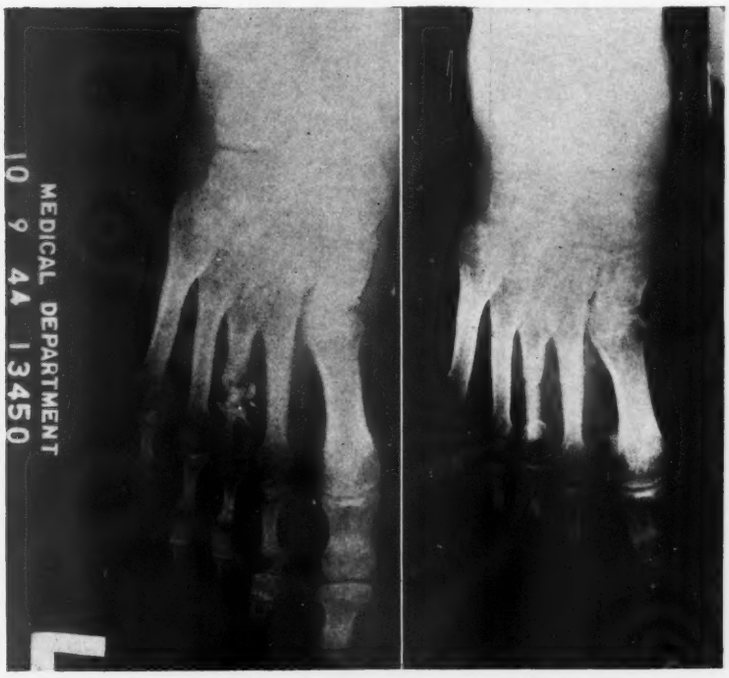

Fig. 30. Fig. 31.

Fig. 30. Case xi. Sixteen weeks after gunshot wound of right foot; non-union, bone defect of third right metacarpal.

Fig. 31. Case xi. Sixteen weeks after bone graft operation; early evidence of union.

studies undoubtedly will have to be made before definite conclusions can be drawn.

Case xii. This patient, age thirty-four, slipped and fell on the icy ground and sustained

Fig. 32. Fig. 33.

Fig. 32. Case xii. Fracture, simple, at junction of lower and middle thirds of tibia.

Fig. 33. Case xii. Primary bone graft of tibia six weeks postoperatively; minimal callus formation; beginning evidence of union.

a spiral type fracture of the right tibia, 6 inches above the ankle joint, and a comminuted fracture of the fibula in its upper third, on December 22, 1944. (Fig. 32.) On December 27, 1944, a sliding tibial bone graft operation was performed after satisfactory reduction was obtained. A high thigh plaster cast was applied. Six weeks later position remains satisfactory. Callus formation and beginning evidence of union of bone graft is present. (Fig. 33.)

CHEMOTHERAPY AND BONE GRAFT SURGERY

Having had an opportunity to see innumerable casualties in the war zone and on the home front, we believe quite definitely that the use of penicillin and sulfonomide drugs have contributed much to the lowered incidence of wound infection. While we do not believe the use of these drugs will cover errors in surgical technic, we do believe that their use has done much to reduce the incidence of infection after well controlled and well performed surgery.

In our patients with clean wounds that have never been infected, we routinely sprinkle the donor site and grafted areas with a light frosting of microcystalline sulfathiazole. Postoperatively, the patient is placed on penicillin and given 20,000 units every four hours for five to seven days. Our incidence of infection has been remarkably low.

In our fractures that have previously been compound and infected, we here again use sulfathiazole as above. Penicillin is given in the above dosage for seven days preoperatively and for ten days postoperatively. Our incidence of infection has been very low. In the past, patients who have been infected and needed further reconstructive surgery were often not brought to final surgery until six months to one year after the infection had subsided. We have operated upon many of these patients three months after the infection and drainage had subsided and here again our incidence of infection has been remarkably low.

We believe that the use of chemotherapy has a definite rôle in reconstructive bone surgery in the prevention of operative and postoperative infection. We strongly recommend the pre- and postoperative use of penicillin and the use of sulfathiazole powder at operation in the operative wound.

POSTOPERATIVE COMPLICATIONS

1. Infection in the past has been the greatest source of failure in bone graft surgery.[16] If the infection is severe and extensive, it is not unusual for the graft to be lost. However, if the infection is well localized, free institution of adequate drainage may often lead to control of infection and saving of the graft which often then goes on to satisfactory union. Chemotherapy has done much to prevent this complication. It has not been our greatest source of failure.

2. *Fractures of the graft* may occur and under some circumstances such a complication may prove serious. Whenever immobilization is not satisfactory, fracture of the graft may be anticipated. The graft probably has its greatest strength immediately after operation. Following operation there is a period of transformation in which the graft becomes more fragile as union progresses. This is followed by a long period in which the graft becomes progressively stronger, thicker and heavier (in accordance with Wolff's Law). In any event the graft becomes much weaker before it gets stronger and if immobilization is not adequate before union occurs the graft may be fractured. This complication has occurred in a few of our patients in whom we placed an onlay graft on the femur. In each instance it was due to inadequate immobilization. One of our patients was a youthful athlete who tried to chin himself on the fracture bed bars despite the fact that he was immobilized in a body cast with a leg spica. Undoubtedly this unusual exercise contributed to his complication. Each patient requires careful watching preferably by the operator.

3. *Fracture of the Donor Site.* Having removed a bone graft from the donor site (tibia), the extremity should be protected from unusual stress or strain for the next few months until sufficient new bone is formed to strengthen the defect. Several of our patients have fractured the donor site when they indulged in unusual and strenuous exercise while on liberty. One patient (Figs. 34 and 35) slipped on the ice and fractured not only the donor site but both "wafer grafts" in his forearm. This complication is most unfortunate for obvious reasons. Here again careful supervision of the patient's activities must be followed if a prolonged convalescence is to be avoided.

SUMMARY

An unusual number of rehabilitative problems have been encountered at the U. S. Naval Hospital, St. Albans, requiring bone grafts. No attempt has been made to present unusual results or procedures.

Fig. 34. Fig. 35.

Fig. 34. Case xiii. Complication—fracture of tibial donor site. Patient slipped and fell and fractured the tibial donor site as well as the onlay wafer grafts.

Fig. 35. Case xiii. Complication—fracture of bone grafts.

Typical cases requiring surgery and an operative corrective method have been presented. Despite lack of prolonged follow-up of many cases, it is believed that the results are uniformly good and justify the operative procedure. Pre- and postoperative use of penicillin is advocated. The use of sulfathiazole powder in the operative site is recommended. Adequate and prolonged immobilization is imperative. Complications were discussed and means of obviating them presented. Bone grafting in many war casualties offers the only possible hope for re-establishment of alignment and function.

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Sound bony union of the scapulo-humeral articulation in the optimum position of abduction in front of the coronal plane ensures a most useful limb which provides power and stability, although its excursions are limited.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

GLASS PLASTIC CAST

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IN a recent article,[1] one of the authors discussed the attributes of an ideal cast, and described a new, open-mesh, waterproof, plastic cast that in most respects met the requirements. The clinical effectiveness of this type of plastic cast has already been established by application to a substantial number of patients at the United States Naval Hospital, as reported by Kulowski, French, and Erickson.[2] In brief, the bandage then reported and the improved form to be discussed here is a knitted, all plastic bandage which, after being wetted with setting solution, hardens into a rigid cast.

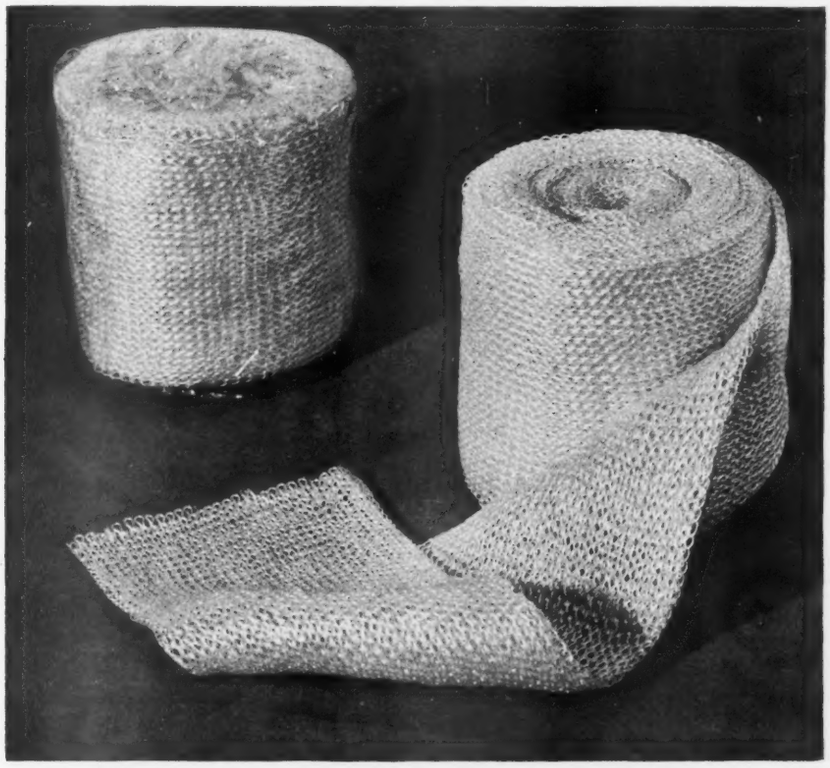

FIG. 1. The bandage is so knitted from glass and plastic fibers that it is flexible, porous, and elastic. Its strength comes from the truss-like design. The bandage is made in several widths and is packaged in cellophane for ease of handling and to keep it clean.

The plastic bandage previously reported had many outstanding advantages, such as resistance to water, lightness of weight, porosity, transparency to *x*-ray, and cleanliness in application. (Figs. 1, 2, and 3.) There were, however, a few drawbacks. For example, considerable care was required in its application, especially to avoid applying the bandage under tension, which sometimes led to contraction of the cast. The spraying on of the setting liquid required considerable time. By modifying the composition of the original bandage, these faults have been eliminated, and the desirable characteristics of the bandage have not only been retained but even bettered.

The modification which has made this major improvement possible is the substi-

FIG. 2. The glass plastic cast can be applied directly to the skin. Although very light, it is surprisingly durable and will withstand a good deal of wear. Soiling can be removed with soap and water. Aire-Lite can be sterilized in the usual manner in the autoclave, and since it can be applied close to or directly over the wound, a new approach to the treatment of wounds, burns, compound fractures, and plastic procedures is provided.

FIG. 3. T. B., Perthe's disease of the right hip. Radiograph taken through an Aire-Lite cast shows only slight obstruction to the rays. The great strength of the material makes it possible to hold major fractures, such as those of the pelvis or upper femur, with such a thin cast that clear radiographs can be obtained. The light weight helps the patient to become ambulatory even when wearing a spica cast.

tution of glass filaments of Fiberglas for the regenerated cellulose or rayon content. While various combinations of soluble plastics, with or without insoluble plastics, have proved successful, the preferred composition is cellulose acetate 80 per cent and glass 20 per cent by weight. Since both the glass and plastic filaments are finer than hair, smooth and flexible, the final knit bandage is soft, flexible, and elastic. By employing a special knitting technic and by regulating the physical-chemical pretreating process and the Fiberglas content, it is possible to capitalize on the elastic characteristics of the bandage so that it can be applied under tension without danger of subsequent contraction.

The bandage is wetted by immersion in the setting liquid just before it is applied. The action of the fluid on the entwined plastic and glass filaments fuses them into a rigid but smooth cast with a cool, silky interior finish. The wetted cast sets and dries considerably faster than did the previously reported type. The completed cast is light and porous. Although the component plastics are heavier than water, the structure of the cast is such that it will actually float in water. (Fig. 4.) The open mesh provides free circulation of light and air.

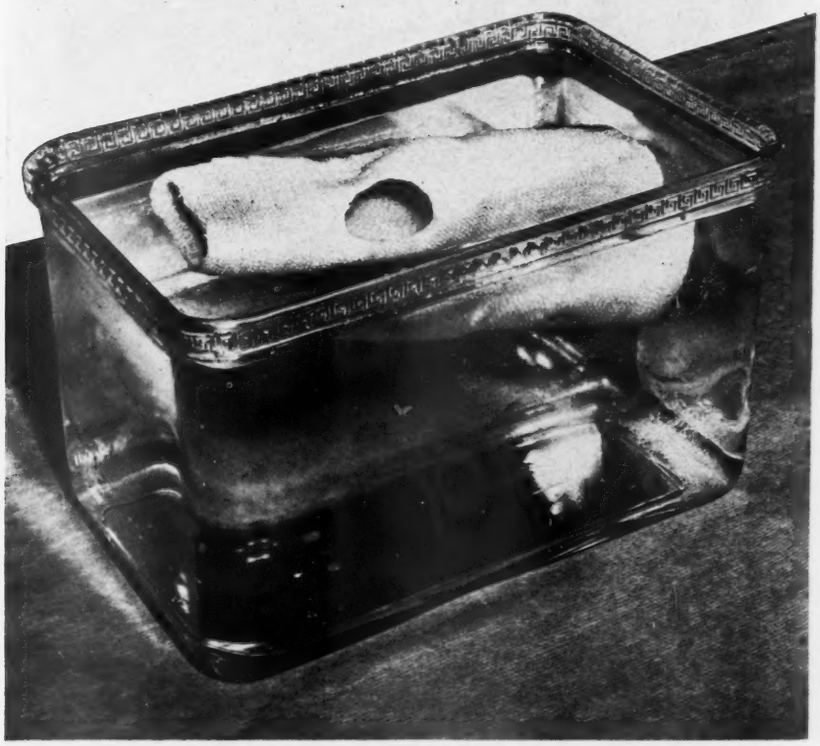

Fig. 4. Although the components of the bandage are slightly heavier than water, the porous structure of a cast of several layers entraps sufficient air to give it enough buoyancy to float.

The setting or welding fluid is clinically a non-toxic solution with a slight wintergreen odor that most users do not consider disagreeable. Although it is inflammable, no greater precautions need to be taken than for ether. The solution is compounded of chemicals with low boiling points to insure rapid evaporation. While various setting solutions can be used, the liquid used at present is a combination of acetone, methyl salicylate, and a group of hydrocarbons. The accurate formulation of this blend defines and regulates its action so

that the glass and plastic filaments will fuse together without the cellulose acetate being appreciably dissolved or softened.

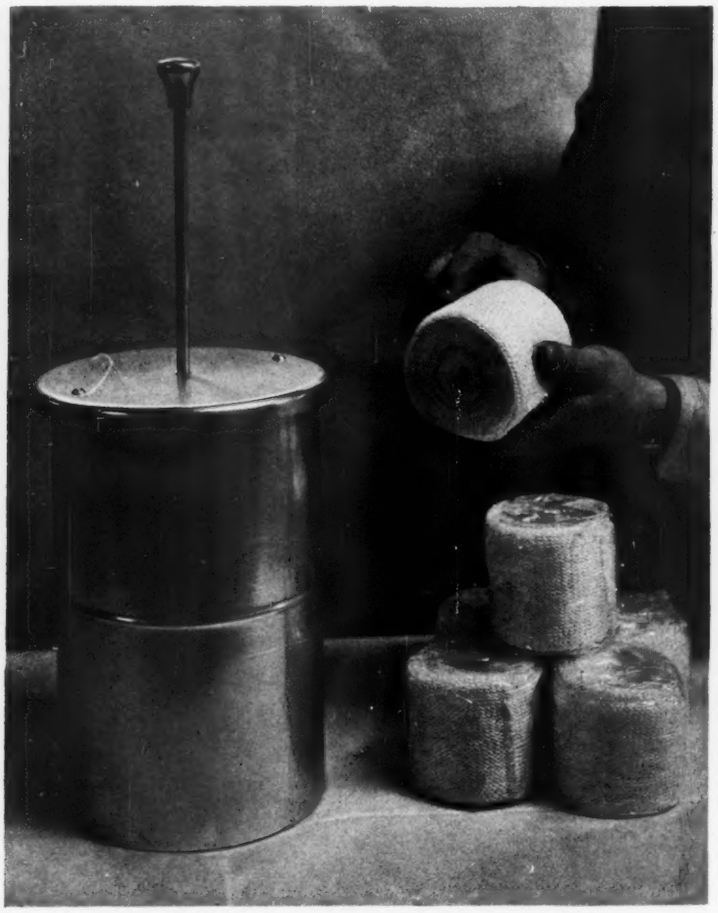

FIG. 5. The bandage is easy to apply. As illustrated, the bandage is wetted by immersion in the Erickson Immersion Can. Since the bandage is elastic, it can be wrapped on under tension so as to conform to body contours.

This permits the cast to dry in a relatively short time.

Regarding possible reaction of the liquid on the body, there are two factors which make it safe to use, as verified by substantial clinical experience: First, the components have been carefully chosen for their non-toxic qualities and non-irritant characteristics, and second, the extreme volatility of the blend, coupled with the designed porosity of the cast, make it virtually impossible to maintain the liquid in contact with the body for more than a few minutes. As for the operator, there have been a few reports of a drying-out action on the skin of the hands from extensive use of the setting liquid, but the authors have had no difficulty. This is easily prevented by the use of rubber gloves or the application of two or three drops of mineral oil to the hands prior to using the liquid.

There have been no reported allergic reactions from wearing of the glass plastic cast, and, judging from experience with plastics in other fields, their incidence should be extremely low. Cellulose acetate has been used in a host of ways in contact with the body, ranging from such items as lingerie and stockings to such articles as teething rings for babies, without appreciable reaction. Fiberglas, too, is quite inert as far as body tissues are concerned. For

example, it is being used without harmful effects in sutures, in surgical sponges, and as a burn dressing.[3,4,5]

Fig. 6. Mrs. J. C., flail lower extremities from a recent attack of poliomyelitis. She is being taught to walk again through hydrotherapy. Later the foot portion of the cast will be removed, and the cast bivalved and applied only during walking exercises.

The question of inflammability of the completed cast is an interesting one. The glass portion, of course, is completely non-inflammable and the cellulose acetate burns reluctantly, especially when in the form of a cast. It burns less readily than clothes or bedding.

TECHNIC

The technic of applying the glass plastic bandage is simple and in a general way resembles that for a plaster cast. It can be quickly learned.

The part to be casted can be padded in the usual manner with sheetwadding. However, since the bandage is elastic, it can be so smoothly and accurately applied that padding is unnecessary. To have a good support for the extremity during application of the cast, stockinet is used, with one end left extended so that it can be held by an overhead support. If stockinet is not desirable, the hand can be supported by means of finger traps. Thin strips of felt can be placed to assist later in wedging, bivalving, or removal of the cast. The bandage can be applied direct to the skin, and when properly applied the inside of the cast will be practically as smooth as a dinner plate. If the skin is dusted with talcum powder, the cast will not adhere to hairs or skin. Since the bandage can be sterilized by the usual autoclaving methods, it can be placed safely over or into open wounds.

The bandage is wetted by immersion in the setting fluid (preferably in a suitable device, such as illustrated in Figure 5). The bandage is immediately withdrawn from the liquid and with some tension it is wrapped in place. After the cast has been

completed, an ordinary elastic cotton bandage is wrapped over the entire cast. The cast is then shaped, smoothed down, and circularly rubbed with the palm for a few minutes, after which the cotton bandage is removed. Setting can be hastened by using a small hair drier.

Disadvantages, fortunately, are few and are not serious impediments to successful use. Their partial if not complete eradication appears a near possibility. The one disadvantage of any concern is that the setting time is slightly longer than that for plaster. However, this is largely compensated for by the fact that an Aire-Lite cast will dry out faster than a plaster cast. Recent improvements have considerably lessened the setting time, and, judging by the trend of continuing research, it will be still further reduced.

The cost of the plastic cast is at present somewhat higher than plaster. However, this difference in cost becomes negligible when all of the cost factors involved are taken into account. For example, with plaster, the need of extra linen and gowns, the laundering expense, the tracking and cleaning of floors and carpets, and the time and expense of frequent cast changes add up to a substantial amount. The outlook is for a continued lowering of the price of plastics as a result of ever increasing technological advances.

Another drawback has been that the process of molding the cast to correct such conditions as club foot or angulated fracture could not be readily done because pressure of the hands would interfere with evaporation. This situation has been met by allowing the elastic cotton bandage to remain in place at the site of the contemplated molding until the adjoining areas have set. When the desired degree of rigidity has been attained in the contiguous portions, the cotton bandage is removed. The usual molding or angular correction is then made, and the soft portion of the cast is left uncovered to harden in position of correction, in the usual manner.

Clinical Advantages. The glass plastic bandage can be used for all types of immobilization and for unusual therapeutic measures.

Since the material is waterproof, the patient can bathe, and the cast can be cleansed with soap and water. In the treatment of poliomyelitis, arthritis, hand and other infections, and most traumatic conditions, hot packs and hydrotherapy can be carried on without disturbing immobilization. (Fig. 6.)

Since the cast components do not absorb liquids or odors, involuntaries of senile or infant patients do not harm the cast and can be removed by washing.

Although an Aire-Lite cast weighs only one-fourth to one-sixth as much as a plaster cast, it is so strong and durable that changes are seldom necessary.

The elastic bandage is knitted with an open mesh and is so processed that it can be safely applied under tension to conform to every contour. It is as suitable for a little finger cast as for a large spica cast.

It is ideal for immobilization of hand and foot injuries and facilitates early return to work because the cast will not soften from absorption of liquids and can be readily cleansed of dirt.

The cast can be cut with an ordinary cast cutter, or, by applying the setting fluid or a softening cream, it can be cut with bandage scissors.

The cast is cool to wear, its porous structure admits light and air, and even when the cast is wet it does not block *x*-ray penetration. It can be used in the tropics because it does not absorb moisture and is not affected by humidity, molds, or fungi.

The bandage can be sterilized in the autoclave, and since it can be applied direct to the skin, numerous improved technics become possible. The preliminary clinical work in these fields shows promise and points to it as a useful addition to the armamentarium of the surgeon. The characteristics of the cast open a whole new avenue of therapy in such varied fields as

the treatment of compound fractures, osteomyelitis, burns, skin plasties, and orthopedic and urological reconstructions.

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AMPUTATION at the wrist should be planned, if possible, so as to save the thumb and a finger or other portion of the hand against which the thumb may be apposed. *Amputation at the wrist* prevents the proper fitting of an artificial hand and wrist mechanism without undue length, and *should be avoided.*

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

METALLIC FOREIGN BODIES AND THE ELECTROMAGNETIC LOCATOR*

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IN the localization and removal of tissue-imbedded metallic foreign bodies there are always certain technical difficulties, and these depend mainly upon such factors as: (1) the source; (2) the site; (3) the size of the invader; and (4) the duration since infliction.

1. *Source factors* derive importance from the velocity, size, depth and consistency in terms of accessibility and actual or potential damage. Steel, iron, lead, copper, brass, tin and aluminum fragments are in order of frequency the most important and prevalent. Fragments from firearm sources usually penetrate more deeply than those from tools or other metallic materials. Bomb, grenade, shell, rocket, rifle, pistol and other military sources, because of their velocity and heat, may inflict damage disproportionate to their size, and also because of their tendency to rotate when they impinge upon tissues that change their direction and impede their progress. This applies especially to bomb and other fragments of irregular shape with sharp or jagged edges. Bullets and others of a cylindrical form usually present an entrance orifice relatively smooth and rounded, but always irregular at the exit orifice when of the so-called through-and-through or in-and-out variety (perforating wounds.) Fragments from tools (hammers, chisels and the like) produce, as a rule, an irregular orifice unless entering on their edged rather than their flat surface. Needles, surgical and sewing, usually penetrate smoothly and denote their site by symptoms directly proportionate to their impact, size and site. Shotgun lead pellets are generally multiple and their entrance site may be smooth or ragged, depending upon their size, velocity and contiguity. Glass, unless with a lead content, fails to be delineated by roentgenologic examination, and penetration by wood fragments follows the same rule because it is unrecognized radiographically unless covered by paint containing a relatively large amount of lead, zinc or copper.

2. *Site factors* are important when the lodgment is close to or within important structures, as, for example, a viscus, strategic vascular or neural vessels, muscles, fasciae, tendons, joints and sometimes bone. A fragment in the palm, finger, foot, toe, cheek or neck may be much more important than the same sized invader lodged in thick muscle. Likewise, joint penetration may prove to be a potential source of danger. When the heart or lung is invaded the effects vary as between a fatality or relative quiescence because tolerance or intolerance follows the rule of being directly proportionate to the site and size of the foreign body. Invasion of the intestine, liver, kidney and other abdominal organs generally is a problem related to hemorrhage and peritonitis rather than that of the residual causative invader. Accessibility of removal is of prime importance as between the let-it-alone policy or removal in terms of initial or problematic effects. Many foreign bodies produce no effects whatsoever and remain quiescent throughout a lifetime; indeed, there are numerous instances in which the individual has no knowledge that an indwelling invader exists and with difficulty recalls a probable source of entry.

3. *Size factors* are of importance from the structure affected and the dimensional

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relationship. This varies as between a tiny fragment in a strategic and usually mobile area, and a large fragment in a relatively unimportant and usually immobile (silent) region. For example, between eye involvement and invasion of the thigh muscles there are wide variables in terms of initial or subsequent implications. Lodgment within closed cavities (skull, spine, thorax, adbomen, joints) may not be the immediate source of concern to the patient or the surgeon, but the potentials are none the less possibilities or probabilities as to remote effects. The tendency toward encapsulation of an invader by fibrous tissue is well known and there is no question that this inclusion locking-up process often provides prolonged immunity and prevents activity in terms of an inflammatory or pressure reaction or change in position, this last producing the fear of "wandering," more often more bothersome to the patient than to the surgeon.

4. *Duration factors* are of importance in terms of the elapsed time since the receipt of injury; this post-traumatic implication is important in any aspect of traumatology.

The *initial* damage may manifest itself as hemorrhage; the *intermediate* effect may be in the form of infection; the *late* manifestation may produce pain, pressure, interference with function, or psychic signs of apprehension and fear because the invader may "wander" or produce "trouble later." Occasionally, the surgeon or the patient may anticipate subsequent abscess or inflammatory reaction long after the initial invasion; however, such an eventuation is clinically improbable after an elapsed period of six months. I have several patients who asymptomatically retain foreign bodies as souvenirs of World War I and II conflict, and many in civilian life who are equally unaware that tool, bullet, buckshot and other metallic fragments are still indwelling. Many workmen are aware that a piece of metal became imbedded years ago and have forgotten the incident until roentgenologic examination for an unrelated, recent injury recalls the bygone occurrence. Likewise, an ancient process is occasionally reactivated by a new injury, as, for example, a female patient of mine who harbored a sewing needle silently in the gluteal region for twenty-seven years until pain following a fall suggested roentgenologic examination. This disclosed a needle broken in two pieces which I removed with the aid of the locator, noting the characteristic black discoloration, incrustation, erosion and the surrounding fibrous tissue inclusion.

The cosmetic effect produced by swelling or nodulation is an occasional element, even when the invader has long been resident, as, for example, when the site is in the cheek, lip, eyelid, forehead, ear or some noticeable equivalent. However, in such an event, the exchange of the operative scar for the initial prominence must be weighed before advising removal.

GENERAL CONSIDERATIONS AND OPERATIVE INDICATIONS

For clinical purposes we can list invaders as being *important*, potentially *dangerous*, or *unimportant*. Further, foreign bodies may be *superficial*, *intermediate* or *deep*, irrespective of their source, site or size. Multiple imbedded fragments are important in terms of their diverse effects and the probability of safe removal of all or some of them.

In general, it can be said that operative procedures are indicated if any invader is actually or potentially damaging or dangerous, and if the removal attempt does not add to the gravity of the situation. This is equivalent to stating that often a let-alone is safer than a do-something policy. Further, the decision is frequently postponed until the possessor becomes aware of trouble because of pain or interference with function. Then, again, a later and more complete roentgenologic survey may cause the surgeon to advise operation, especially if there has been a change in the position of the invader. The fear of direful consequences is often aroused in the patient by some fanciful account of the

meanderings of a metallic fragment that years ago entered the sole of the foot, for example, and finally reached the groin or even the heart. The travels of needles as recounted by some newspapers and magazines are usually far more romantic than anatomic. The clinical fact is that the vast majority of imbedded fragments remain at their original site, imprisoned in a fibrous encapsulation. However, it cannot be denied that wandering does occur, and this is more prevalent in a mobile than an immobile site, and more common with cylindrical objects as compared with flat objects. Needles and materials of this general size and shape will infrequently change position if imbedded in an area subjected to repeated motion, especially if residing under the fascial coverage of thin, elongated muscles, as in the forearm, arm and leg. When cavities are involved and the invader is more or less afloat or unanchored, the chances for change of position may be very great. In one patient a needle had been located by *x*-ray, in the anterior part of the knee joint not far from the place of entry. Despite the aid of the locator, I could not find it; later, *x*-ray exposures showed it to be in the posterior part of the knee and this site was verified by the locator and removal was then easy. Broken wires, nails, pins and screws used in the treatment of fractures are known to have wandered far afield. In some reported cases they were inserted near the shoulder and subsequently were located in the thoracic region. Others escaped from the hip area and penetrated into the pelvis and even involved the bladder. However, these events are clinically exceptional, and it can again be confidently asserted that the general rule is for a foreign body to remain permanently domiciled or interred in its original resting site.

Therefore, operative removal depends upon the factors dangerous or damaging in respect to the immediate, intermediate or late consequences. However fixed these surgical indications may be, we are often confronted by the patient's fear complex and this, as stated, may compel an attempt at removal. Usually this problem arises in connection with compensation and allied legal cases; and my experience is that the average patient prefers removal to non-removal if assured that the operative procedure is reasonably safe and certain.

METHODS OF LOCATING FOREIGN BODIES

Clinical signs, such as site of entry, swelling, local tenderness, local induration, pain on motion and pressure are valuable, but often disappear after a lapse of a few weeks. Occasionally, the invader remains palpable indefinitely and in some cases a muscular contraction may make it visible.

Radiographic examination is, of course, the determinating factor, as disclosed by fluoroscopy or radiography. The former is less reliable than the latter. Repeated fluoroscopic examination may be harmful to the patient and the observer, hence, caution is needed as to frequent exposures.

Film examination should be in several directions, making certain that the axes are predetermined so that the operative approach will depend upon the liaison between the surgeon and radiographer. It is equally important to have films made in the axis on which the patient is lying during the proposed operation, and following same the patient is to be moved or transported with the possibility that the object of the search may shift if the invaded area is unduly disturbed.

The usual films are made in two axes, as a rule, anteropostero and side-to-side, so that the site and depth determination may be fixed at right angles. However, oblique axes, as stated, are often needed, so that instead of the usual North to South and East to West directions, we may also have other compass markings. Another delineation is clockwise, as from 12 to 6, and 3 to 9; or from 2 to 8 and 10 to 4. Various opaque markers are often placed on the exposed surface and their site is noted by iodine or other staining, or by ink or indelible pencil. Similarly, wire mesh of known interspacing may be used and less often, a needle or probe is introduced so

that a fixed line of approach may be indicated. In open wounds opaque material is sometimes injected along the suspected tract, but this is generally an unreliable method unless the route is quite narrow. Location by *x*-ray tube-shift, the double exposure and the triangulation process are probably the most reliable of all, if made by an experienced radiologist and clearly interpreted to an understanding surgeon. In some cases fluoroscopic search with the patient on the operating table is the chosen method, but this is obviously quite troublesome unless the set-up is unusually replete and complete. However, despite very accurate preoperative *x*-ray aid, it is frequently impossible to retrieve the offender, and this usually is because the operative procedure shifts or displaces the object. Retraction and palpation are the two chief factors in displacing the fugitive, especially if the fragment is small, flat, mobile, or even when invested by fibrous tissue difficult to distinguish visually or digitally from normal markings or the nodules from ligated vessels. Hence, the search should be by clean dissection, when possible, with a minimum of palpation and retraction. In recent cases especially, a bluish or dark discoloration may furnish a clue; and in the case of large fragments, a cicatricial band may be suggestive.

My own experience has been that an apparently easy situation sometimes proves very hard; and the reverse also applies, with the result that assurance of success is usually problematic. Magnets, special probes and sundry devices are often unavailing in the solution; and until the locator device was perfected, success still remained in the problem stage. The precision finder, which will now be described, has been used by a number of surgeons under trying conditions and is worthy of extended use.

THE LOCATOR

This is an electromagnetic device perfected for me by an ingenious inventor in the electrical field, Samuel Berman. He was formerly in the electrical engineering department of the New York City Transit System, of which I am the Medical Director. The impelling need for an improved searching device arose from the frequency with which employees of the System required surgical attention for the removal of imbedded metal accidentally acquired during the course of their employment.

The initial model was first successfully used by me at the Reconstruction Hospital in November, 1941, to remove metal fragments from the ankle region of one of the policemen injured in the World's Fair bombing incident of July 4, 1940. Incidentally, this victim had 167 fragments imbedded in the front of his body from scalp to toes, and most of these small objects still remain *in situ*. This original locator was brought to Hawaii to be demonstrated at a series of lectures given by me as a guest of the Honolulu Medical Society. However, less than four days after my arrival, the fateful Sunday of December 7, 1941, the Pearl Harbor Attack, gave abundant opportunity for proving the value of the apparatus at the Army Tripler General Hospital, where I was soon assigned to active duty as Colonel, Surgical Consultant. Subsequently, several of the Army surgeons, on two successive days, retrieved bomb and other fragments from more than a score of casualties. My own most impressive result while there was in the removal of a machine gun bullet imbedded between the lumbar spine interspaces, causing partial paralysis of the lower extremity and the bladder.

The present apparatus represents many improvements over the original models, and it has now been considerably improved so that more than ever it resembles a portable radio in appearance and action.

Essentially, the device has a search *probe* (present model has two of differing sizes), an instrument board with several *knobs* for circuit adjustment and a *dial* indicator to register the approach of the probe to the

foreign body. Sterilizable rubber envelopes are applied over the probe when used within the wound. A built-in amplifier affords very high sensitivity and a small loud speaker supplements by *sound* the visual indications of the dial. A *red panel light* indicates when the *plug-in wire* is connected and the *ground wire* is attached to a convenient ground (water pipe, steam pipe, etc.). The apparatus is set up in a few minutes and is ready for use wherever electric current is available. The present model operates on 110 volts A.C. only, but special models can be built for operation on 110 volts D.C., 6 volt storage battery, or on dry batteries. (Fig. 1.)*

Sensitivity to Various Metals. The locator is extremely sensitive to the magnetic metals (iron or steel). A mass of ½ mm. diameter is readily detected from a distance of 2 mm.; an ordinary pinhead (about 2 mm. diameter) from a distance of ½ inch; a full length common sewing needle from about 1½ inches; broken sections of stainless steel hypodermic needles from ¼ inch to about an inch depending upon their length and composition (such needles are generally of rather low magnetic susceptibility). Platinum needles and some non-magnetic alloy needles now in use are not detectable with this apparatus. The maximum range for large masses such as hemostats, etc., is about 4 inches.

The sensitivity of the present apparatus to non-magnetic metals (copper, aluminum, brass, lead, etc.) is relatively slight, although still useful at times. A copper one-cent piece or a .45 caliber lead bullet is detected from a distance of about ½ to ¾ inch; a silver twenty-five-cent piece from a little over an inch. Small vitallium screws are not detected. Improvement in this field is proceeding rapidly and laboratory models are now available with a relatively high sensitivity to non-magnetic metals. These will detect a .22 caliber lead bullet from about ¾ inch, and a .45 caliber lead bullet from nearly two inches. These experimental units have already been used successfully in the surgical removal of small caliber lead bullets, but it cannot yet be foretold when their production will be possible.

Method of Using the Locator. After the apparatus is set up, the probe is passed over the suspected region and the point giving the maximum response is marked on the skin. The usual method for quickly determining the surface localization is by moving the probe successively over the site from two directions at right angles, marking lines on the skin to coincide with the two "peak" positions of the probe. The intersection of the two lines is the surface localization. It is further possible to determine the axial alignment of an elongated foreign body, such as a needle parallel to the surface, by the fact that a much greater response is obtained when the probe is parallel to the foreign body than when it is at right angles to it. Accordingly, by rotating the probe over the marked spot the axial alignment of the foreign body is determined by the probe alignment which produces the maximum indication.

Depth Estimate. Two methods are available for estimating the sub-surface depth. A rough estimate may be obtained directly by noting the maximum meter reading at the marked spot, and moving the probe laterally along the skin surface until the reading drops to one-half that value. The distance moved laterally is roughly equal to the sub-surface depth. For example, if a maximum reading of 7 is obtained over the marked spot, move the probe laterally along the surface until the reading falls to 3½. The lateral distance between the probe and the marked spot is then roughly the same as the sub-surface depth of the foreign body.

A more accurate method is to choose a metal sample which closely matches the foreign body in composition and in dimensions as viewed in the *x*-ray film. Note the maximum reading of the meter over the marked spot on the patient and, holding the matched sample in the hand, approach it with the probe until the meter reading

*Since this article was written a new model has been devised which will operate on A.C. or D.C. current or a storage battery.

is the same as over the marked spot on the patient. The distance between the probe and the test object is then the same as the sub-surface depth, accurate to within a tenth of an inch. Since electromagnetic waves penetrate most solid matter (bone, soft tissue, rubber, glass, etc.) with practically the same degree of freedom as air, the accuracy of this test is unaffected by the intervention of tissue in the patient.

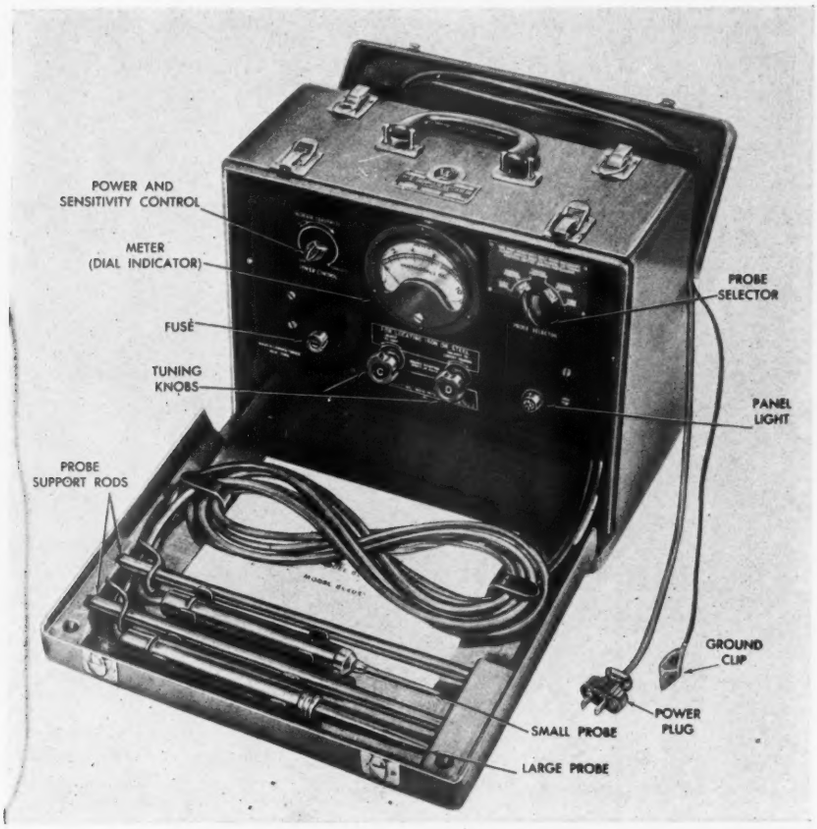

Fig. 1. Locator showing the various elements in the carrying case; size 15 by 13 inches; weight 25 pounds.

OPERATIVE TECHNIC

Obviously, no attempt at removal should be made in the presence of infection unless the foreign body is responsible for the infective process; in effect, the invader then acts like a sequestrum in osteomyelitis.

Preliminary roentgenologic examination, as stated, should be as close as possible to the time of operation, especially if the area invaded is of the mobile type or a cavity is involved. This overcomes the possibility of wandering or shifting in the time interval between radiography and operation. Likewise, the involved area should be kept as immobile as possible in the immediate preoperative period, hence, splintage is often valuable. The patient should be placed on the operating table in the same position as when on the *x*-ray table, and the more experienced the operator the closer will be the liaison with the radiologist.

Before the preoperative cleansing is done, the locator determines the surface location of the invader and this spot is marked by an indelible pencil or other indicator. Personally, I prefer anesthesia by pentothal, followed or reinforced by an inhalant, if necessary. Local infiltration may be used in certain cases, however, as, for example, in a finger or some other easily delimited area. Usually, a tourniquet is unnecessary. The locator is, of course, no source of explosive danger when an inhalant anesthetic is employed. The area involved should be raised 8 to 10 inches above a metal-topped table.

The *incision* may be straight or curved (I prefer the latter) and is centered over the previously marked spot. The extent of the initial exposure, naturally, depends upon the site, size and depth of the invader. Bleeding vessels are controlled by fine ligatures. The field is suitably protected by fastening the drapes to the skin by sutures, leaving uncut about six inches of some of these to act as retractors so that there will be no extraneous metallic material to interfere with the action of the locator. (Fig. 2.) The probe of the locator, covered by the sterile rubber protective, is now introduced into the wound and its point is moved about until by the dial and sound registration we are directed as to the further approach. We follow the lead thus given by sharp dissection, avoiding, if possible, any palpation or retraction within the wound cavity. If retraction becomes necessary, wooden tongue depressors or special plastic retractors are used, in addition to the threads previously attached. If now the sterile locator probe directs us to proceed further and leads to a depth beyond view, my practice is to use a thin artery clamp, the point of which is placed alongside the tip of the probe before the latter is withdrawn. Usually, I fasten this artery clamp into a bit of tissue at the site indicated so that a better clue is provided. A finger now cautiously introduced in this region may palpate the fugitive; if not, further incision and exposure in this area proceeds. The sterile probe is reintroduced if this additional route proves unavailing and, thus, by repeatedly following the direction indicated by the locator, the invader is finally unroofed and extracted. Instead of the artery clamp, it is feasible in some cases to use a wooden applicator which is placed at the tip of the probe as the latter is withdrawn. As stated, wide or deep retraction is very prone to displace the hidden object, and indeed palpation or rough sponging may act likewise. The field should be kept as dry as possible, and often a suction apparatus in a cavernous region may be

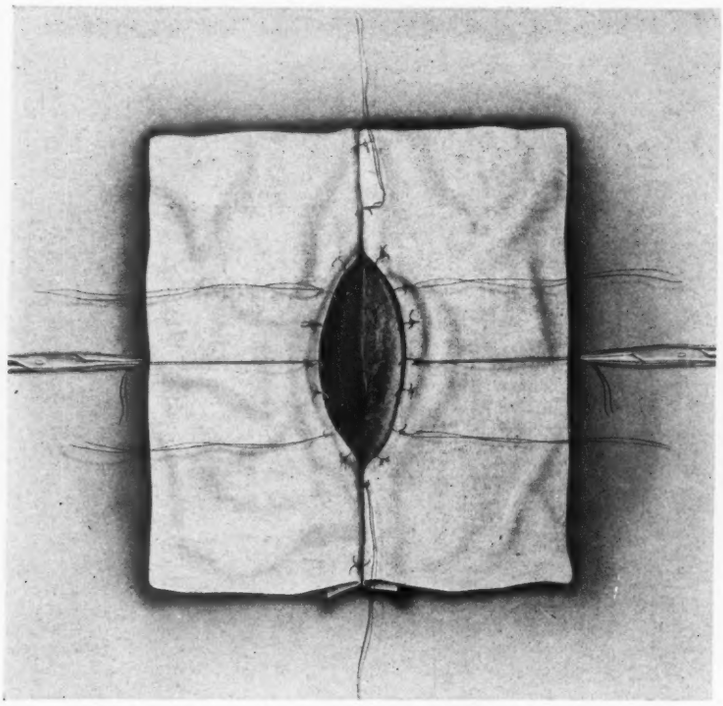

FIG. 2. Method of draping the operative field showing long sutures to be used for retraction, thus avoiding magnetic effect from metallic retractors.

helpful. With patience, adequate exposure and proper use of the locator, the percentage of failures should be very small.

lem. In one case reported to me the radiograph failed to show any foreign body, but the locator indicated a tiny fragment, and

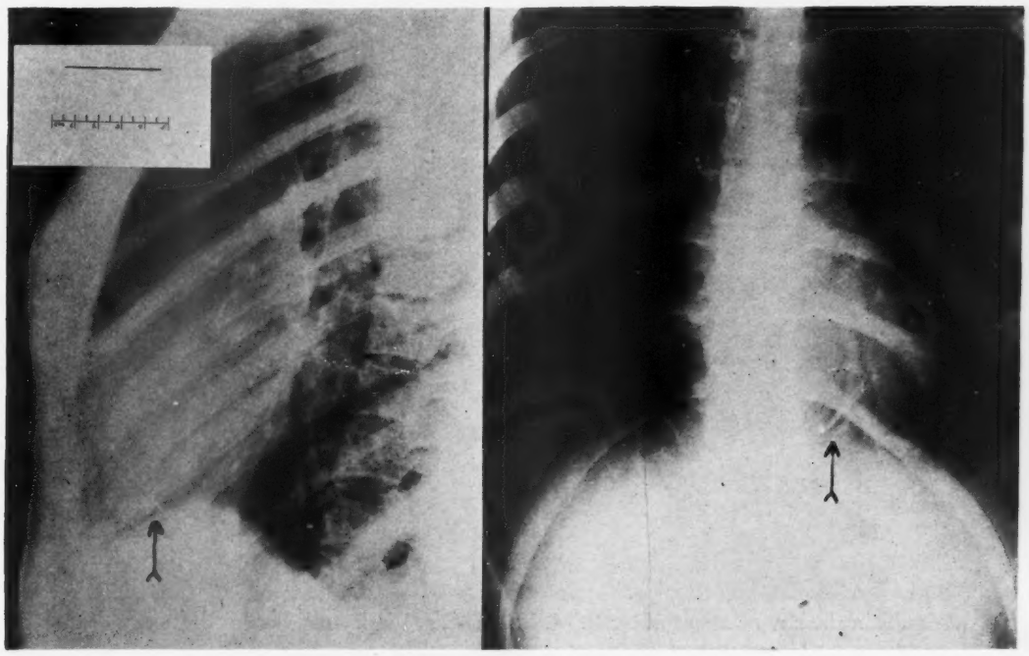

Fig. 3. Needle in the heart. Patient of Dr. A. E. W. Ada (St. Luke's Hospital, New York City).

Closure of the wound is by standard procedures; and if there has been a prolonged search or there is any question of infection, a small drain may be inserted between the interrupted, non-absorbable skin sutures, which are removed within three days.

A heavy dressing, with or without splintage, is an additional safeguard, especially when the source of the penetration is suspect. The use of a sulfonamide or penicillin within the wound is a matter for the surgeon's judgment.

The preoperative use of tetanus antitoxin in suspicious circumstances (as in bullet wounds) is a necessity and if more than two weeks elapse since the initial anti-toxin was administered, it may be prudent to administer an additional preoperative dose.

FOREIGN BODIES IN SPECIAL AREAS

Eye cases have yielded many locator successes, and in this region the difficulty of accurate localization has always been an especially important and puzzling problem. In one case reported to me the radiograph failed to show any foreign body, but the locator indicated a tiny fragment, and this ophthalmic surgeon successfully removed it by this device. In this area the difference of a few millimeters often determines the outcome so that super-accurate localization is more necessary here than elsewhere.

Heart cases have thus far afforded only one notable opportunity, this being a patient of Dr. Alexander E. W. Ada, of St. Luke's Hospital, who successfully removed a needle from the left ventricle by the aid of the locator. (Fig. 3.) This was one of the most dramatic operations I ever witnessed, and this patient was subsequently shown at the New York Surgical Society, March 8, 1944.

Intrathoracic cases have been relatively numerous and the facility with which the locator probe can be introduced has been of signal aid in localization. (Fig. 4.)

Intraspinal cases, likewise, have been notably successful and in this region the difficulty in localization and removal of broken needles has long been recognized. (Figs. 5 and 6.) In such cases particularly,

palpation must not be resorted to, as the needle may easily be pushed deeper, even into the spinal canal. Adequate exposure, good light, a suction apparatus, and everything that will aid visual inspection with a minimum of tissue manipulation should be employed. It has been found advantageous to sterilize a duplicate sample section of the same type needle and keep it at hand on a sterile sponge for checking the proximity of approach as the operation proceeds. This dial reading within the wound is compared with that of the sample from time to time, and in this way the surgeon knows when he is almost contacting the end of the needle. Final approach should preferably be made from the side rather than from directly above. This caution applies to the manipulator of the search probe, as well as to the surgeon.

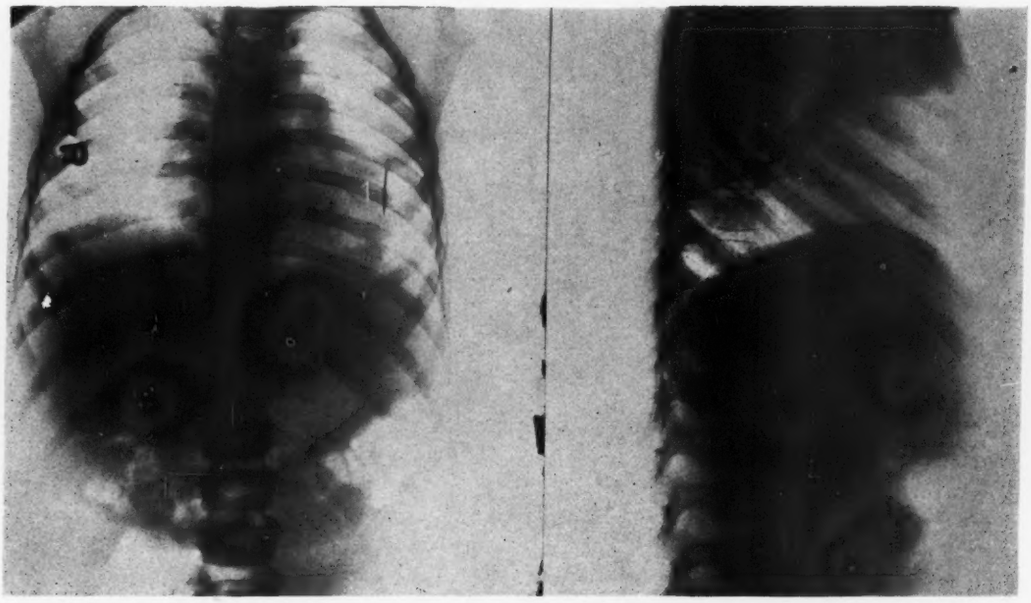

FIG. 4. Needle in the lung. Patient of Dr. J. M. MacKellar (Englewood Hospital, Englewood, N. J.).

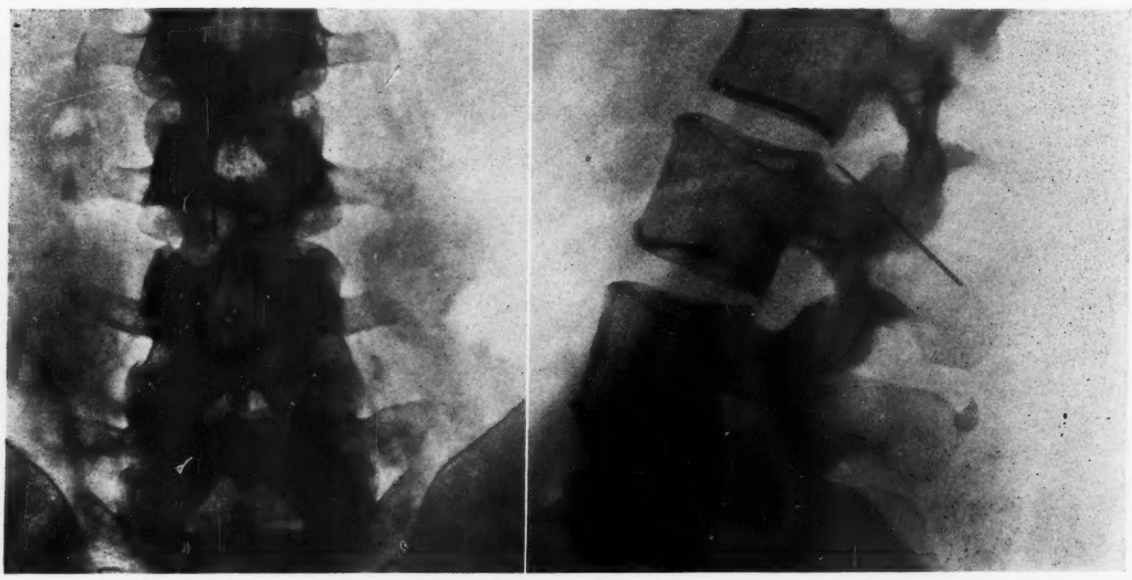

FIG. 5. FIG. 6.

FIGS. 5 AND 6. Broken intraspinal needle. Patient of Dr. J. K. Skiles (West Suburban Hospital, Oak Park, Ill.).

In addition to the surgical possibilities, there is frequently the prospect of a malpractice suit, and indeed this is a feature common to many operations when a needle has been broken or an instrument has been left in a cavity.

Hypodermic needles have been broken and left imbedded in various regions, some of them by diabetics who self-administer insulin, and in this group the locator has been of frequent service.

Gynecologic cases in which a surgical needle has been broken in performing a perineorrhaphy, have also afforded several opportunities to prove the worth of the apparatus.

Intrathoracic and intra-abdominal cases as yet have not been featured, but in many

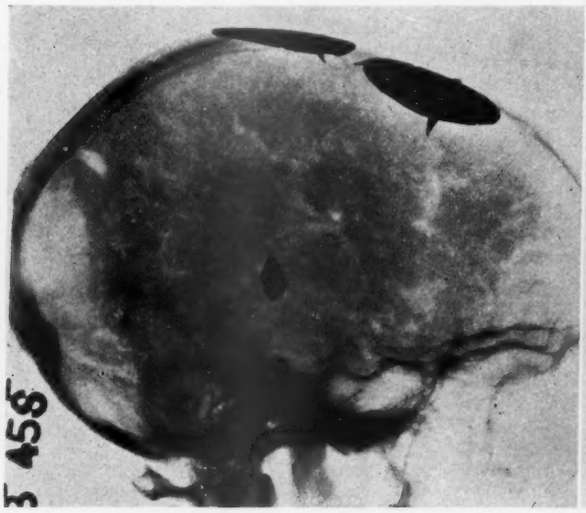

FIG. 7.

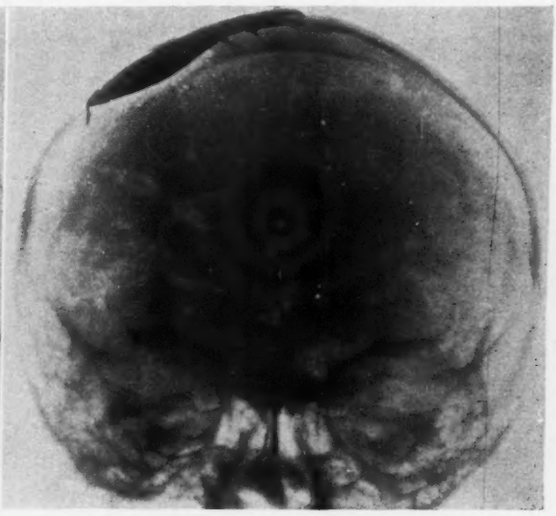

FIG. 8.

FIG. 9.

FIGS. 7, 8 AND 9. Shell fragment in mid-brain, showing size, site of entry and place of lodgment.

cases of foreign bodies in the respiratory or gastrointestinal tract the device should prove useful. This should apply especially to the location of pins, needles or other metallic objects in the trachea, bronchi, lung, esophagus, stomach and intestine. Obviously, the size and depth of the invader will be determinative. However, there is no question that the locator can be helpful in this troublesome group, either before operation or when the involved area is exposed so that the probe can be introduced. It probably is feasible to attach a steel segment to intubation apparatus, such as the Miller-Abbott device, to indicate more accurately where the distal end of the tubing resides and thus avoid the necessity for repeated roentgenologic examination.

Neck cases assume importance because of the mobility of the so-called ribbon muscles and the contiguous respiratory and deglutitory mechanism. In one case a fragment was lodged in the region of the thyroid, according to the radiographic interpretation, and this patient was to have been used by me for a demonstration of the locator. However, the day before the prospective operation the patient coughed up the offender.

Brain cases also provide another field in which the sterile probe will become actively helpful.

At the Neurological Hospital Dr. C. B. Masson has very recently removed a shell fragment deeply imbedded in the midline of the brain of a soldier. (Figs. 7, 8 and 9.) This neurosurgeon asserts that without his previous favorable experience with the locator he would not have ventured to operate on this battle casualty. In this case, the cauterization of bleeding vessels obviated the use of clamps which would have interfered with the action of the locator.

Fig. 10. Fig. 11.

Figs. 10 and 11. Bullet in gluteal region.

Military cases have been numerous, but, obviously, details as to many of these are not yet forthcoming. The rule in front line activity is to remove the missile at the time of the initial débridement, if feasible. However, if the condition of the patient or time does not permit, the removal of the invader is postponed. Thus, in the front line zone, in the base zone and in the post-war period there will be many casualties in which extraction of foreign bodies will be necessary. In the sorting or triaging of military casualties a fluoroscopic or radiographic examination is routine when circumstances permit. However, by the use of the locator large groups of suspects can be quickly sorted to determine the presence of residual fragments and, thus, the triaging can be accomplished with great speed and accuracy. (Figs. 10 and 11.)

It must be remembered, however, that because the effective range of the locator

is considerably less than the *x*-ray, a negative result with the locator is by no means conclusive of the *absence* of a foreign body. A positive indication, on the other hand, not only determines the *presence* of the missile instantly, but localizes it at the same time with utmost accuracy.

To date, the greatest known mass use of the apparatus was after an explosion in which 202 foreign bodies were removed from fifty-five patients within two days.

Priority limitations until recently permitted the civilian use of the apparatus only on a lending basis, but now the manufacturers* have a limited supply available.

The combined use of *x*-ray and the locator finding device has greatly reduced the incidence of failure and has brought the search for imbedded metallic material into the zone of assured success. To date, in 173 cases there has not been one negative result when this device has been used by some eighty-three surgeons in the metropolitan and adjacent areas. In many cases the locator was successful after previous efforts were unavailing. So far as is definitely known, there is no other available apparatus activated on the same principle, although in Germany there is said to be a device based on radio activity which has been successfully employed by military surgeons. The English, according to recent correspondence with me, have been using, with indifferent results, an apparatus similar to that said to be employed by the Germans.

A further development of the locator may be successful in extracting the foreign body after it has been located.

CONCLUSIONS

1. A device is described by which metallic foreign bodies can be located more accurately, thus supplementing the use of *x*-ray localization.

2. This apparatus is of special service when the suspected area has been exposed at operation, notably because the preoperative *x*-ray localization is then less reliable, inasmuch as the fugitive is often displaced by the operative procedure.

3. The operative technic is described and special caution is enjoined so that palpation and retraction may not displace the object sought.

4. The device has a unique field in locating foreign bodies in difficult sites, notably the eye, heart and lung.

5. A precision approach is possible with the locator so that the operator can now have a greater assurance of success outside of and also within the operative area.

6. There is a wide field for this device in civilian, as well as in military, surgery, and in the post-war period its zone of usefulness will greatly increase.

7. Before using, it is essential to test the device by locating foreign bodies purposely imbedded in modeling clay, sponge rubber, sections of meat or other materials. Like any other precision instrument, the locator responds best when used with knowledge, skill and experience. It can be confidently asserted that failures are chargeable to the user more than to the apparatus because the underlying scientific principles involved are unerringly accurate.

* Waugh Laboratories, New York City.

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EMBEDMENT OF A VITALLIUM MANDIBULAR PROSTHESIS AS AN INTEGRAL PART OF THE OPERATION FOR REMOVAL OF AN ADAMANTINOMA*

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UNFORTUNATELY there are conditions in the mandible, where diseased and adjacent tissue must be removed, regardless of disfiguring facial sequelae. It seems only such sacrifice would save or prolong the patient's life. An analogous situation is to be discussed. It is of especial interest, because at the time of the excision of an extensive adamantinoma, and as an integral part of the surgical procedure, a mandibular vitallium prosthesis was inserted and attached to the remaining mandibular segments. The appliance was substituted for the removed bone and was itself embedded or buried within the soft tissues. Thus, some of the usual dreadful consequences following a radical resection were obviated.

"An adamantinoma is a locally malignant tumor of the jaw. Adamantinomas may be solid or cystic or a combination of both and are sometimes called multilocular cysts, multilocular cystomas, or ameloblastomas. A solid adamantinoma is slow growing, occurring more often in the mandible than in the maxillae, is well encapsulated and does not metastasize. The cystic adamantinoma develops from the solid adamantinoma by cystic degeneration of the epithelial portion of the tumor. Because of this, epithelial cysts and bubbles are formed which are usually found in the body of the jaw. Originally there are many separate cysts present and the adamantinoma, therefore, shows an uneven lobulated contour. These cysts are of various sizes, ranging from small cystic cavities to extremely large ones, even extending through the entire mandible. These tumors may appear at any age, but they usually occur between the ages of 20 and 30 years."[1]

CASE REPORTS

L. L., a female, aged fifty-five years, was referred to us. She complained of intermittent, excruciating pain in her mandible. The lower third of her face was distorted, her mandible seemed to be irregularly prognathous. Although she had been edentulous for many years, her lower lip did not shrink. (Fig. 1A.)

Her medical history dated back twenty-six years to 1918, when a small lump which did not cause her any pain was noticed on the right side of the mandible. This was treated and observed for a few years. However, ten years later (1928), the patient did complain of pain on the same side of the mandible which proved to be a recurrence of the previous lesion. To treat this condition, an extra-oral operation was performed. Then three years elapsed (1931), when a large fluctuating diffuse mass which extended from the anterior border of the right ramus to the left premolar region had to be excised. The clinical diagnosis was "multilocular cystic tumor." To supplement the surgery, several courses of radium radiation and roentgen therapy were administered. Two years later (1933), a bluish cyst 1 cm. in length was noticed in the right sublingual gland. An *x*-ray examination disclosed another recurrence. The procedure followed in 1931 was repeated, i.e.,

* From the Fourth Surgical Division, Bellevue Hospital, New York City.

conservative intra-oral surgery supplemented with radium radiation and roentgen therapy. The previous treatment notwithstanding, in February 1943, the patient again complained of intermittent pain in the mandible to the left of the symphysis. An oral examination revealed a small cystic swelling which seemed to be continuous with and part of a larger mass. The larger mass occupied the submental region immediately to the right of the mid-line. The *x*-ray report in July 1943, comparatively described the lesion as "considerably increased in area."

A B

Fig. 1. A, front view of patient showing irregularly prognathous mandible. B, moulage of patient with door-like sections opened to show the intra-oral swellings.

In the winter of 1943, our oral examination revealed an edentulous mouth. Her tongue was displaced distally. The entire mandibular alveolar ridge was considerably swollen and irregularly distorted. (Fig. 1B.) The mass was widest in the median line beneath the frenum linguae to the mucolabial fold, measuring 32 mm. in diameter. It narrowed slightly toward the canine regions, then extended laterally in both directions to approximately the second molar region on the left measuring 22 mm. from the lingual surface to the mucobuccal fold, while on the right, the swelling continued to the retro-molar region measuring 27 mm. in the same linguobuccal direction.

Our roentgenograms revealed multiple cystic formations divided by bony trabeculae and multiple bubble formations. The growth involved the entire body of the mandible from the crest of the alveolar ridge to its inferior border. In some regions, notably the anterior, there was no visible cortical bone. The picture was typical of adamantinoma of mandible. (Figs. 2A and 2B.)

Previous conservative surgery apparently was only temporary in its effectiveness. Obviously, the roentgen therapy and radium application did not result in the anticipated cure of the tumor, or prevent its recurrence, or limit its growth. In view of the extensiveness of the neoplasm, there was no choice but a radical surgical operation.

We realized that with the removal of so much mandibular bone, the facial and neck muscles would lose their basic support, and there would be a collapse of the lower part of the face. Thus, their normal co-ordinated function would cease, and thereby would seriously hamper such essential functions as breathing, mastication, and talking. These mutilating consequences would produce a caricature-like physiognomy. The prominence of the face and its obvious nakedness would further aggravate the situation. Moreover, we were fully cognizant that in no part of the

human body does alteration in contour cause an individual more despondency than its occurrence in the face.

be borne in mind. For other patients,[2] the most trying period followed the resection, when they recognized their deformity. The

FIG. 2. A, roentgenogram of left side of mandible showing the extension of adamantine formation to approximately the second molar regions. B, roentgenogram of right side of mandible revealing multiple cystic formations, divided by bony trabeculae and multiple bubble formations. Note there is no cortical bone in anterior region.

Therefore, a truly realistic and positive approach for the care of the patient was impelling. A keen appreciation of her mental health as well as the surgical hazards had to

depression continued until they were persuaded that a prosthesis would help them. During that interim, their anguish and dejection were greatest, the mental and physiological adjust-

ment most difficult. To obviate such undesirable conditions, something had to be anticipated to be used at the time of the operation which could preclude facial collapse, and thus maintain facial contour and regional functional constancy.

To accomplish such an objective, a thorough study was undertaken. Impressions of the maxillary and mandibular jaws, a plaster facial cast, and a facial index were taken. A special effort was exerted to include not only the full oral extent of the tumor, but also the adjacent tissue. With the facial index giving the relationship among the various parts, i.e., maxillary and mandibular models to the face and head, a composite moulage was made. (Fig. 1B.) Thus a reproduction of the patient was had which could be studied from different planes, and whenever desired. Similarly, additional information and guidance were furnished by the various roentgen plates.

Any device to be made from the foregoing study had to possess not merely adequate physical properties and physiological potentialities, but most important, it had to have the overall purpose of serving as an essential psychic prop.

As prerequisite, the prosthesis should: (1) be completed prior to the operation and be ready for insertion at the time of operation with a minimum of adjustment necessary; (2) be of a material tolerated by tissues in order that it could be embedded permanently within them; (3) take the place of the removed bony tumor and adjacent bone; (4) be attachable to the remaining healthy mandibular segments; (5) stabilize the remaining parts so as to enable them to function as a continuous single united bone; (6) be strong enough to support and withstand the stress of the musculature previously attached to the diseased bone; (7) possess provisions for the attachment of those muscles to it, and (8) possess adequate bulk for facial contour, but of limited dimensions to permit the complete closure of the surrounding mucous membrane and muscles.

These requirements could be generalized thus: The artificial mandibular section had to be compatible with and tolerated by the tissues, and be of such physical properties, mechanical construction and design as to anticipate changes to be produced by the mandibular resection.

To meet these requirements, vitallium, a procurable patented metal, of light specific gravity, was selected. From Venable and Stuck[3] we learn: "Vitallium is an alloy of cobalt, chromium, and molybdenum which was

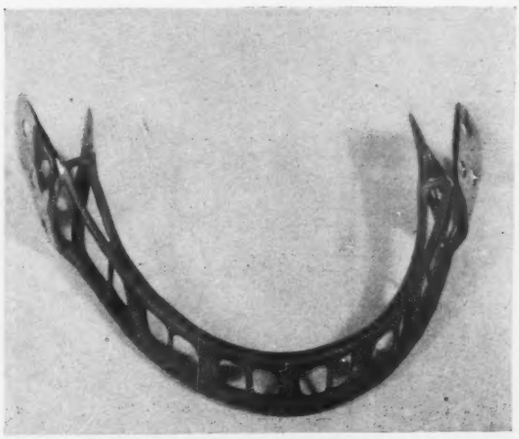

Fig. 3. Photograph of the vitallium mandibular prosthesis. Note the interspaces for joining the muscles, tie wires for sutures, and flanges with screw holes for attachment to remaining bone segments.

developed by the Austenal Laboratories of New York for dental plates. It contains no iron and is entirely resistant to body fluids. There is no corrosion of the metal itself or irritation of the tissues about it. We encountered it in our experiments on the effects of electrolysis of metals on bone in 1936, and because of its inertness, we advocated its use for bone plates and screws." This metal could be processed into the special pattern needed for our patient. Therefore, the impressions previously taken were also utilized to make a facial plaster cast with dental inserts. The maxillary and mandibular models were set into the facial cast so that each model could be removed and replaced into position when desired without destroying the composite cast.

The full length of the inferior border of the mandible from angle to angle was marked on the patient's face. A lead wire was conformed to this line. The lead wire was then transferred to the corresponding part of the facial cast. Tracings of the rami and mandible from the *x*-ray plates were also outlined on the facial cast. On the mandibular model, the oral extent of the swelling was noted.

With these models and markings available, a wax pattern was carved for the prosthesis. It consisted of a body to replace the removed bone, and two sets of flanges extending backwards. For all practical purposes the body

resolved itself into two heavy wires, an upper of shorter circumference, and a lower one of larger circumference, contoured from above downward by bridging sections and joined by smaller tie wires, thus providing ample suture attachments for muscles at the time of operation. At either end, the wires terminated in two buccal and lingual flat-ended flanges to grasp the anticipated left and right remaining bony segments of the mandible. All flanges had screw holes. The buccal flange was used to fasten it to the ramus with vitallium screws, while the lingual flange served to overcome the tendency of the mandibular segments to be pulled upward and inward, thus increasing the mechanical advantage by lessening the mechanical stress on the screws. The lingual flanges alone could not be used as they were surgically inaccessible for fastening purposes.

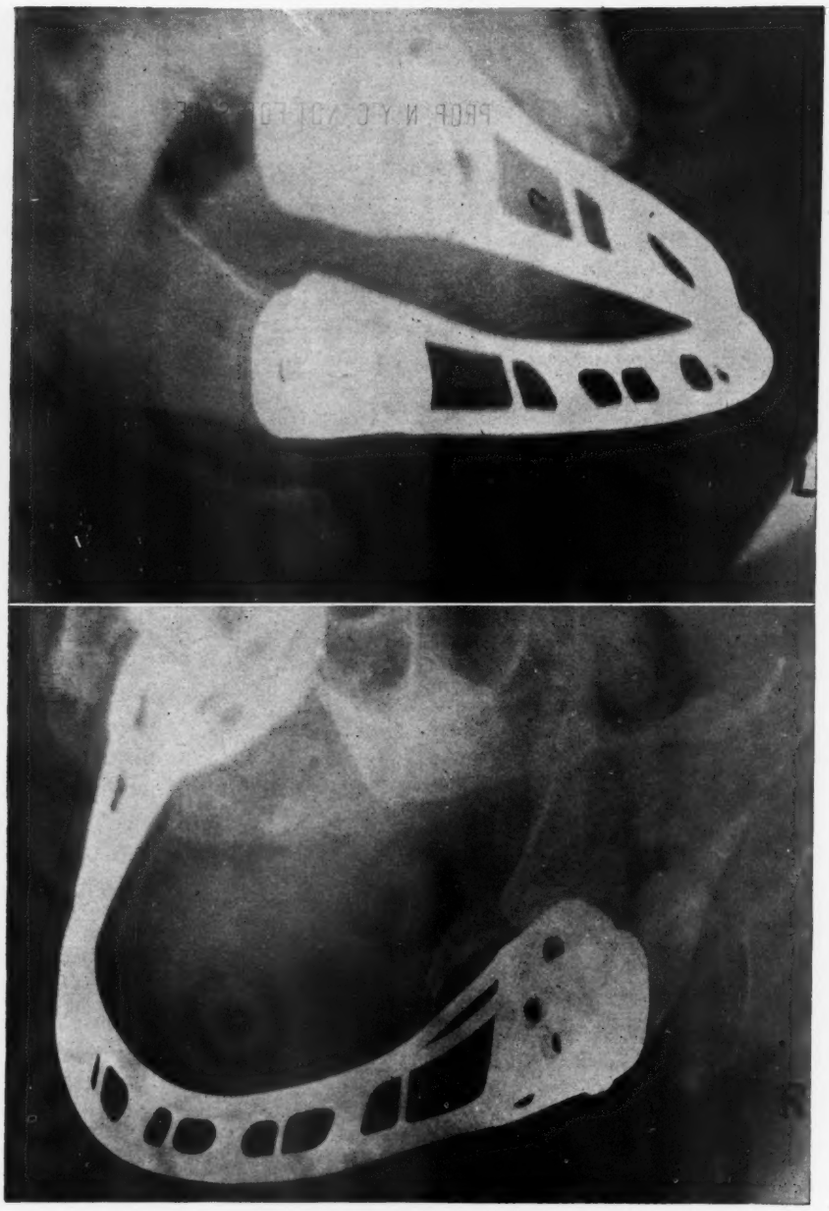

FIG. 4. A, left lateral roentgenogram showing the appliance in position and the left flanges attached to the left mandible. B, right lateral roentgenogram also showing the appliance in position with the right flanges attached to the right ramus.

With all the provisions we could anticipate included in the wax pattern, the prosthesis was cast in vitallium metal. It was completely

processed and made ready for insertion. (Fig. 3.)

We were, therefore, ready to proceed. Before doing so, however, it had to be borne in mind that secondary hemorrhage, in some instances fatal, followed extensive mandibular resection. As a preventive, the right external carotid artery was ligated seven days prior to the resection,[4] and the left facial artery was ligated at the time of the resection.

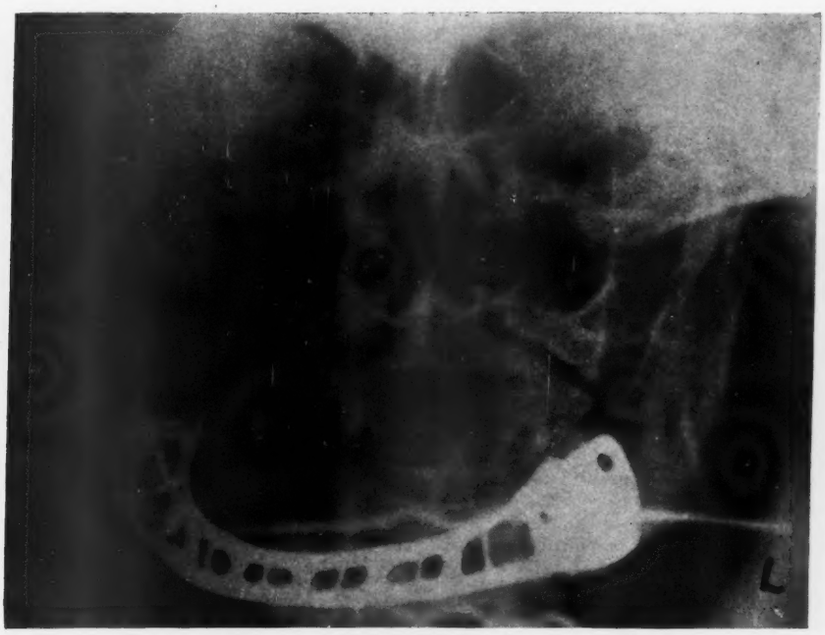

Fig. 4. C, postero-anterior roentgenogram showing the appliance in position. Note the vitallium screws through the flanges attaching the appliance to the remaining mandibular segments.

Thus with the problem of hemorrhage under control, the patient was prepared, and the mandibular resection was performed. A large external incision was made along the inferior border of the mandible through the skin and muscle down to the bone extending from the left angle to the right angle. The left facial artery was tied off. All the muscles attached to the external and internal surfaces of the body of the mandible were freed from the bone revealing a large tumor mass. With a Gigli saw, the bone was cut in a safe, healthy zone distal to the diseased part. The mandibular prosthesis was then fitted into place and an attempt made to center the appliance in the median line and in the horizontal plane. Its flanges were adjusted to their respective segments and set into place. With vitallium screws, two on each side, the artificial metal mandible was secured to the remaining mandibular bone. (Figs. 4A, B and C.) Thus the free segments were joined together and stabilized. The oral mucosa was closed. The muscles previously attached to the body of the mandible, i.e., the mentalis, triangularis, digastric, mylohyoid, genioglossus, and geniohyoid, were joined through the interspaces of the metallic replacement, and sutured to its tie wires from the median line along its entire length.

With interrupted sutures, the external wound from angle to angle was closed. The patient had an uneventful recovery. *X*-rays were taken and show the appliance in position. (Figs. 4A, B and C.) Her facial contour is fair. (Figs. 5A and B.) She can open her mouth (Fig. 5B) and talk. Her muscular function is rather favorable and is constantly improving. Of greatest importance, there was no interim of depression apparent to us; the patient seemed cheerful and appreciative.

SUMMARY

1. The extent of the adamantinoma and the patient's previous history provided no alternative but a drastic radical resection of the mandible.

2. The mandibular metallic prosthesis was planned, its contour and method of attachment, etc., anticipated, and its con-

struction entirely processed prior to the operation.

3. To prevent excessive bleeding and secondary hemorrhage (sometimes fatal), the external carotid artery was ligated one week previous to the resection.

4. At the time of resection, and as an integral part of the operation, the metallic prosthesis or artificial jaw was joined and attached to the remaining mandibular segments uniting them into a single functioning unit. It also replaced the removed bony structure.

5. The inserted mandibular section completely prevented the usual facial collapse and other sequelae, and most important, eliminated the usual period of depression following a mandibular resection.

A B

FIG. 5. A, front view of patient after resection with appliance buried in the soft tissue. B, front view of patient after resection with mouth open.

CONCLUSION

There is only a brief interval since the removal of the adamantinoma involving the whole body of the mandible in which to determine permanent benefits from the immediate insertion, attachment, and embedment of a vitallium prothesis (artificial metal jaw). Nevertheless, the maintenance of the patient's mental health and the prevention of a caricature-like physiognomy thus far, warranted that plan of treatment. It furthermore suggests a method of approach for those hopeless individuals for whom bone grafts are unfeasible, and a manner of maintaining segments of the jaws for those who eventually might benefit from bony transplants.

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THYROID CRISIS*

PATHOGENESIS OF HEPATIC ORIGIN

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IT is the duty of members of a house staff to undertake the major portion of the burden, in the pre- and post-operative care of patients. Early in our hospital careers our interest was enlivened by a clinical entity often associated with a tragic finale. Few syndromes are more fulminating, more formidable, or more lethal, than thyroid crisis.

In the preoperative preparation of patients with exophthalmic goiter and in the care of persons in thyroid crisis, it was realized that much of our treatment was inadvertently directed toward fortifying the liver. This fact stimulated interest in the liver and its possible relationship to hyperthyroidism and thyroid crisis.

Most of our conclusions were previously formulated by laboratory investigators. We have taken the knowledge gleaned from the laboratory and applied it to our clinical observation of the thyroid patient.

DESCRIPTION

Zondek[1] was the first to describe hyperthyroid crisis and coma. He stated that this syndrome is characterized by marked motor restlessness with uncoordinated movements of the entire body, associated with a rapid rise in temperature, and a lack of reactivity on the part of the patient. Increased obnubilation may lead to a syndrome which resembles catalepsy or bulbar paralysis.

The clinical picture of storm, according to Means,[2] is that of a fulminating increase in the symptoms of thyrotoxicosis. The pulse may rise to 200. The patient is very irritable, often delirious, but at the same time weak to the point of collapse. Coma may supervene and death occur. A prominent feature of storm is hyperpyrexia. In contrast to the usual preservation of heat in the presence of heightened metabolism in thyrotoxicosis, during crisis the mechanism breaks down and the temperature rapidly ascends to between 100 and 106°F. or more. It is to be looked upon, as in hyperpyrexia of sunstroke, as due to toxic destruction of the body's organization for eliminating heat. The entire course of a storm from the initial symptom to death may be only a few hours. Recovery is possible, but not the rule.

Lahey[3] called attention to the early signs of an impending crisis. A persistently unexplained increase in pulse rate is a definite indication of a threatening thyroid crisis. When a thyroid patient begins to show vague, transient but definite periods of irrationality an impending crisis may be in evidence. Vomiting may be another prodromal sign. This indicates the inability of the individual to take in fluids and food and thus to combat the effects of the increased combustion associated with thyroid disease. A patient with a definite diarrhea likewise becomes a candidate for a crisis because even though fluid and food be taken, they are rapidly lost as a result of the diarrhea. The metabolic balance is not maintained, hyperthyroidism becomes intensified, and the danger of a crisis is imminent.

Crile, Jr.[4] summarized this state: "A thyroid crisis is a vicious circle of hyperthermia and hypermetabolism. With each degree of elevation of temperature, there is an increase of 7.2 per cent in the B.M.R., and with each increase in the rate of

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metabolism there is a proportionate increase in the production of heat by the body." Under these circumstances the patient burns up his tissues, until he is exhausted.

THEORIES

As in many problems associated with the physiodynamics of disease, the exact cause of thyroid crisis is unknown. With this uncertainty, no general agreement as to etiology can be postulated. This has resulted in many theories according to the experience of investigators who have studied this entity.

Herget,[5] in 1940, reviewed the various theories promulgated by Europeans. Among the eccentric theories quoted was one by Just. This author stated that "the rise in temperature (in crisis) is due to the operative trauma in that disintegration of proteins takes place and leads to irritation of the heat center." Herget further reveals that many authors up to the writing of his article believed that crisis is due to postoperative hyperthyroxemia. This hyperthyroxemia may be provoked by many factors. Among these provocative causes he mentions: (1) Operative manipulation of the thyroid gland which mechanically increases thyroxine in the blood, and (2) reflex influence on the hormonal secretion by injury to adjacent nerves.

Bier (quoted by Herget) assumed that hyperthyroid coma actually constitutes a hypothyroxemic shock due to lack of active thyroid hormone. Sauerbrüch (quoted by Herget) attributes crisis to a sudden reduction in the hormone concentration after subtotal resection. This leads to a disturbance of endocrine and nervous equilibrium producing postoperative crisis. Kappis (quoted by Herget) stressed a shift in the ionic equilibrium toward the acid side as a participating factor in the causation of crisis.

The thymus has been accused as the etiological agent in crisis by Kocher (quoted by Herget). He observed thymic hyperplasia in more than 50 per cent of deaths from Basedow's disease. Garré and Borchard elaborated upon this thought by stating that anoxia is produced in patients with a persistent thymus. This acts on the heart and produces an increase in the effect of thyroid secretions. Garré (quoted by Herget) was able to cure patients with Basedow's disease by extirpation of the thymus. Foss and associates[6] studied this problem and concluded that: "while so-called thymic death does not resemble in many respects death from thyroid crisis, the majority of patients dying in crisis will be found, at autopsy, to have a persistent and hypertrophied thymus."

Herget[5] likened crisis to an allergic or anaphylactic reaction. He believed that crisis might be prevented in the same way as the anaphylactic shock of serotherapy and can be avoided by preliminary injection of a small desensitizing quantity of serum.

McGregor[7] thought that an underlying polyglandular stimulation in certain adolescents resistant to iodine was a factor. Thus he stressed preoperative radiation of the pituitary and adrenal glands with satisfactory results. In keeping with this endocrine concept, Nash[8] called attention to the antuitary. He maintains that thyroidectomy causes the antuitary to produce an increase of thyrotrophic hormone plus other hormones. This postoperative outpouring of potent antuitary substances may induce the so-called thyroid crisis, "one or more of the hormones having probably a greater influence in this direction than the others."

Further thoughts on the relation of the thyroid gland to other glands attracted interest to the adrenals. Levy[9] was the first investigator to demonstrate that injections of adrenalin cause an action current in the thyroid gland. In addition he pointed out that thyroid secretion renders more excitable the sympathetic nerve endings which are acted upon by adrenalin. It has been further revealed that glycosuria in animals as a result of the administration of adrenalin disappears after excision of

the thyroid, the glycosuria reappearing, however, when the animal is fed thyroid extract. There is known to be a reciprocal inhibition between the thyroid and the pancreas on the one hand and between the pancreas and chromaffin system on the other.[10]

The adrenalin test of Goetsch[11] is based on the work of Levy who showed that the sympathetic nerve endings in hyperthyroid disease were abnormally sensitive to small doses of adrenalin. Further evidence to support the adrenal-thyroid relationship was found by Goetsch and Ritzmann.[12] Hyperadrenalism whether due to psychic influences, anoxemia or other causes, may exert some influence in the precipitation of thyroid crisis. Prevention, therefore, of both disturbing stimuli and anoxemia is essential to the well-being of the thyrotoxic patient. The evidence offered by Goetsch and Ritzmann indicates that adrenalin should not be given in thyrotoxicosis.[13] Additional studies by Maddock and his associates[14] increase the evidence in favor of the adrenal theory. Substantiating the relationship between the adrenals and thyroid crisis, Rea[15] has employed spinal anesthesia in the treatment of thyroid crisis. This procedure is offered on the basis that spinal anesthesia temporarily denervates the adrenal glands. The observations by Brace and Reid[16] bring forth additional clinical evidence regarding the ergototoxine-ergotamine-adrenalin relationship.

In 1936, Lahey[17] reiterated the hypothesis that hyperthyroidism was allied to hyperiodinism. The work of the Lahey Clinic chemist, Perkin, on blood iodine and its relation to toxic thyroid states is widely known. He found that in normal individuals thyroxine is confined to the thyroid gland; in toxic states increased thyroxine is found circulating in the blood. The low amount of iodine in the thyroid tissue represents a state in which the thyroxine produced in an excessive amount is rapidly discharged from the thyroid. Thus when patients are improved or relieved of their hyperthyroidism, there is an immediate increase in the amount of iodine stored within the thyroid gland. These facts fit most satisfactorily into the theory of hyperiodinism representing hyperthyroidism.

Other concepts of thyroid crisis have been offered for consideration. Ewald[18] ascribes postoperative crisis to a sudden "flooding of the organism" with thyroid secretion, but he suggests that perhaps it is really due to sudden deprivation of thyroid secretion instead. The theory of Letchford[19] stating that crisis is due to thyroid failure appears to have little basis in fact. Pedersen studied the work of Schneider[20] on the serum sodium content and it was not corroborated. It was apparent to Pedersen[21] that determinations of the serum sodium have no value in relation to hyperthyroidism. Maddock and his associates[22] thought crisis might be explained on ionic disturbance. However, their experiments led them to conclude that searches for abnormalities in inorganic ion concentrations in blood have not been revealing.[22]

All the theories advanced as to the etiology of thyroid crisis have not satisfactorily answered the numerous questions associated with this phenomenal syndrome. In the quest for the answer to some of these questions many investigators have been attracted to the rôle of the liver in thyroid disease.

THE HEPATOTHYROID RELATIONSHIP

The correlation between the largest gland in the human body, the liver, and the potent cervical endocrine gland, the thyroid, was not suspected until 1905. Since that year pathologists and laboratory investigators called attention to pathological changes in the liver associated with hyperthyroidism. Both experimental and histological evidence was offered to associate the liver with thyroid dysfunction. In spite of all the evidence presented, clinicians and surgeons ignored the proffered benefits derived from the laboratory

and theorized as to the etiology of thyroid crisis.

The stream of experimental pathological studies began in 1905. In that year Schryver[23] observed a greater degree of autolysis in the livers of thyroid-fed than of control animals at the end of twenty-four hours. Farrant[24] (1913) found that thyroid-fed cats and rabbits in which a modified picture of exophthalmic goiter had been produced, exhibited at post-mortem examination, in addition to other changes, fatty degeneration of the liver, most marked around the center of the lobules. In the same year, Cramer and Krause[25] noted that excessive thyroid administration resulted in glycogen depletion of the liver. Kuriyama[26,27] studied the effect of thyroid feeding on white rats and found that within three to five days practically all of the animals exhibited a decreased glycogen content of the liver. Hashimoto and Goodpasture (1921)[28,29,30] fed albino rats and rabbits thyroid substance in an endeavor to produce histological changes in the myocardium. To their surprise both workers produced parenchymatous changes in the liver. Goodpasture reported a clinical case of hyperthyroidism which exhibited at autopsy progressive atrophic cirrhosis of the liver with numerous vacuolated nuclei suggesting glycogen depletion. Haban (1935)[31] was able, by thyroid feeding, to produce necrotic changes in the livers of cats and rabbits. In addition he observed a total depletion of glycogen content. These findings were confirmed experimentally by Zeldenrust and Van Beek.[32]

Additional scattered reports have been recorded in the literature to establish a definite thyrohepatic relationship. Cameron and Karunaratne[33] published an extensive study on this relationship based on thirty cases. These investigators attached no special significance to their studies. They considered the pathological finding of necrosis as evidence of a severe toxemia based on atrophy and cirrhosis. Roessle[34] postulated an hypothesis that in the presence of thyrotoxicosis a toxin is elaborated which acts on the liver because of the detoxifying function of that organ. Parturier and Delerue[35] stated that 30 per cent of all patients with hepatic disease present signs and symptoms attributable to the thyroid gland. They believed that, from clinical observation, the effect of the thyroid on the liver is less marked than the effect of the liver on the thyroid: "Thyroid function is unlatched only when hepatic function fails."[35] Rome[36] called attention to the frequency with which thyroid failure is complicated by various types of hepatic dysfunction. An analysis of 107 autopsies for toxic thyroid disease was made by Beaver and Pemberton at the Mayo Clinic.[37] From their survey they believed that in most instances the lesions in the liver appeared to be an integral part of the syndrome of exophthalmic goiter and to be due directly to thyroid intoxication.

More specific elucidation of the pathological changes in the liver due to thyroid disease was forthcoming. Weller[38] described the usual liver lesion as an interlobular fibrosis with lymphocytic infiltration. Among the reports published on the study of liver damage in patients who died of thyroid crisis is that of Youmans and Warfield.[39] They reported liver damage in four and jaundice in three of five patients who died in crisis. Assmann[40] distinguished a type of hyperthyroidism associated with a rapidly lethal outcome. In these cases the more severe conditions passed into acute atrophy of the liver. Mahorner[41] reported an interesting case of exophthalmic goiter in which jaundice was a prominent finding. The fact that it disappeared within a month after thyroidectomy suggested to him that liver damage can be caused by thyrotoxicosis, and that adequate therapy can restore the liver to normalcy. Foss and associates[6] in a study of eleven cases of thyroid deaths found but one normal liver in the cases of true crisis.

The above resumé of the literature associated with hepatic disorders in thyrotoxicosis, strongly indicates a definite relationship between these two organs. Hence it can be appreciated that both the experimental and pathological evidences previously enumerated indicate a direct relationship between toxic thyroid disease and liver damage. Whichever one is accepted as the causative factor is not of primary concern. Investigators appear more interested in discovering some method by which the state of the thyroid patient can be estimated in terms of the hepatic factor. For this reason attention has been given to formulating laboratory tests on liver function in the thyroid patient.

LABORATORY TESTS ON LIVER IN THYROID DISEASE

Possessing a tremendous reserve capacity, the liver has the ability to function in the presence of extensive parenchymatous damage. For this reason an efficient test of hepatic efficiency must of necessity be most sensitive. In the pursuit of the ideal test many procedures have been offered.

In view of the fact that the maintenance of a normal blood sugar is a most important function of the liver, it is preserved to the very end.[42] Of the tests on carbohydrate function the galactose tolerance test has been most favored.[42] Judd[45] considered that methods for detecting hepatic injury in relation to sugar metabolism were so unreliable as to suggest that they affected only the reserve capacity of that organ.

Urea is formed in the liver, and uric acid is presumably formed and destroyed in that organ. Thus it might be expected that blood urea and uric acid determinations would be a secure calibration of early hepatic dysfunction. However, such determinations are of little value until liver damage is far advanced.[42]

Other studies on hepatic function involved tests for cholesterol. The normal values for blood cholesterol are usually 200 mg. of cholesterol and 100 mg. of cholesterol esters per cent. Formerly, variations of from 30 to 50 per cent in the ratio were considered normal; but now it is believed that the free cholesterol in normal individuals is usually not greater than 30 per cent of the total.[42] Changes in the ratio are more important than changes in the concentration of total cholesterol, since the esterification of cholesterol esters from cholesterol and high fatty acids is accomplished in the liver. Pickhardt[44] and his associates found the cholesterol of the blood serum to be a very valuable index of hepatic reserve, as did Sperry,[45] whereas other observers have stressed the ester cholesterol.[42]

More specific liver function tests were studied in attempting to evaluate the hepatic status in hyperthyroidism. Serum protein values of thyroid patients have been studied by several investigators. Bartels found the total serum proteins below normal in 63 per cent of the patients he studied.[46] This protein depletion was noted when the patients were first seen and in 37 per cent of the cases after ten days of therapy.[46] Bartels observed a definite relationship between the level of total serum protein and the severity of the hyperthyroidism as indicated by the necessity for surgery in stages. Further studies on the inorganic sodium content of blood serum in hyperthyroidism were made by Pedersen.[20]

The importance of iodine and its relationship to hyperthyroid states has been mentioned previously. With this association in mind most interesting studies have been evolved about the blood iodine test. Data have been accumulated which point to the liver as a factor in iodine metabolism.[47] Experimental evidence has been offered to indicate that the liver is involved in normal iodine metabolism. Maruno[48] has stated that iodine is excreted with bile. Yuzuriha[49] maintains that the reticulo-endothelial system is concerned with the removal of iodine from the blood.

With these studies as a background De Courcy[50] attempted to correlate elevated

blood iodine to disturbed liver function. This investigator pointed to the liver as a potent factor in the regulation of blood iodine and speculated, in the absence of proof, that the activity of the reticuloendothelial system might play an important part. He has tentatively assumed that when the iodine content of the blood is below 100 micrograms per 100 cc, operation can be done with reasonable safety as far as the liver status is concerned.[50]

Of all the tests employed in studying hepatic function in thyroid disease, the most satisfactory procedure is the Quick hippuric acid test of detoxifying function. This method has been employed extensively and successfully at the Lahey Clinic and by Boyce.[42] Boyce used this test in 130 cases of thyroid disease.[51] He concluded that hepatic dysfunction in hyperthyroid disease is more frequent and more serious than was generally realized. He postulated that the progression or regression in function, as exhibited by serial Quick tests, corresponds to clinical improvement or lack of improvement. The degree of hepatic dysfunction is usually related to the clinical severity of the disease, and to the degree of toxicity as exhibited by the basal metabolic rate.[51] Improvement in liver function occurs in patients who respond clinically to preparation for operation. This he believes to be a useful test in evaluating the results of therapy. In the employment of the Quick test it is important to know that its greatest value is derived when it is used serially. When it is used in this way, it is possible to state that a patient is a good or bad risk from the hepatic standpoint. It is also possible to determine, from the response to treatment as expressed by this test, whether the risk has improved, remained stationary, or has become worse.[42]

From all the evidence thus far presented, it is evident that many isolated studies have pointed to the importance of liver function in toxic thyroid disease. The various tests employed indicate that hyperthyroidism has a damaging effect on the liver.

CLINICOPATHOLOGICAL EVIDENCE FOR THE HEPATOTHYROID CONCEPT

In the presence of the universal and frequent experimental results, clinicians were late to grasp the full significance of the laboratory evidence in support of the hepatothyroid association. The liver and thyroid have a common anatomic relationship in that both are glands. Experimental physiopathologists, and later clinicians, have discovered a closer interrelationship between these organs than would appear from this casual anatomic fellowship.

It is only within the last decade that the literature has contained clinical references to the hepatothyroid correlation. Surgeons now recognize that the liver in thyroid disease is of significant importance. Many of them have believed that deaths occurring in hyperthyroidism are chiefly liver deaths. Boyce[42] likens thyroid crisis to "liver shock" type of death which sometimes follows surgery of the biliary tract. Connell[52] believed that the syndrome of rapid hyperpyrexic death occurred only after biliary tract surgery. However, he soon abandoned this view and believed it could occur in many other operations.

Hyperpyrexic death may follow operations in badly prepared patients. It has been allied to thyroid crisis because the clinical picture closely simulates the syndrome seen in untreated or mistreated toxic thyroid disease. As to the cause of this calamity of thyroid crisis, Boyce suggests that the toxic overstimulated metabolism results in combustion of the protective glycogen of the liver beyond the degree of safety.[42] When this point is reached there develops sudden and extreme hyperpyrexia, an almost uncountable pulse, vomiting, and diarrhea. Restlessness may supervene which may pass into delirium, coma and death.

Other authorities have concurred in the thyrohepatic relationship. Both Criles[43] and later Dinsmore[54,55] have remarked that

liver failure is the most common cause of thyroid delirium, mental confusion and death in thyroid crisis.

The younger Crile expressed this concept as a problem of hepatic failure and metabolic exhaustion.[4] He emphasizes the possibility of jaundice. Visible jaundice may be present in some cases, whereas, in others repeated determinations of icteric indices may fail to show any increase above normal levels. If the icterus index is not elevated, there is no way of relating the syndrome to the liver and hence it is called "metabolic exhaustion." If the presence of jaundice is noted, it is classified as "hepatic failure."[4]

Lahey[56] has stated that he is more and more certain that deaths due to hyperthyroidism are chiefly liver deaths. He has adduced in support of this thought not only the clinical picture of crisis, but the efficacious utilization of intravenous glucose to combat the excessive combustion resulting from hyperthyroid states. He believes that with excessive hyperthyroidism goes excessive combustion and "when fluid and fuel intake is inadequate to meet this excessive degree of combustion, progressive autocombustion occurs with exhaustion of available glycogen and diminution of the glycogen reserve in the liver."[3]

Additional studies have been made in substantiation of the close relationship between the liver and hyperthyroidism. An intimate association between thyroid crisis and functional changes in the liver was suggested by Lord and Andrus[57] on the basis of their study of the plasma prothrombin level in thirty-six patients with hyperthyroidism. Frazier and other surgeons[58–61] at the University of Pennsylvania published important results on the therapy of thyroid disease as directed to the liver factor. Studies by Bartlett[62,63] confirm and emphasize the importance of liver damage in toxic thyroid disease.

Early studies on the pathological picture of the liver in thyroid disease originated in the experimental laboratory. With the influence of adrenalin in thyroid disease as a guide, Perrazzo, in 1934,[64] was able to produce advanced fatty degenerative changes in the liver. At that time this finding was considered to be the major pathological lesion observed in many fatal cases of hyperthyroidism. Perrazzo accomplished this experiment by the intravenous injection of moderate doses of adrenalin.[64]

Shaffer in a study of the livers from twenty-four fatal cases of toxic thyroid disease, found a loss of liver weight, fatty infiltration, cirrhosis, and lymphocytic infiltration in the periportal region often associated with patchy fibrosis.[65] Webster and Chesney[66] have shown that when rabbits are fed a diet rich in cabbage a marked degree of goiter results. Examination of these thyroid glands showed a considerable degree of hyperplasia which was considered to be compensatory. According to Marine[67] the active principle in the cabbage is a cyanide. Thyroid hyperplasia and even exophthalmos may be produced in young rabbits by the injection of cyanides, which greatly lower the oxidation in body tissues. Cyanide is toxic to the liver and herein may be the cause for the hepatic picture produced by these investigators which was analogous to the findings of Shaffer.

Boyd has summarized the major pathological hepatic picture in thyroid disease: "There is no constant pattern in the liver lesions, but they are essentially congestion and degeneration. Fatty degeneration is extremely frequent. There may be acute necrosis, both focal and central. Subacute toxic atrophy may occur, with the development of cirrhosis and nodule formation."

ANOXIA AND HEPATIC DISEASE

The increased metabolism of the thyroid patient has been indicted for the facility with which these individuals develop anoxia. Recent literature has witnessed several excellent monographs demonstrating the pathological changes wrought in the liver subsequent to anoxia. Under such conditions of hepatic anoxia, the damaged

liver appears to accelerate the thyroid gland to hyperactivity. In a situation of this type a mutual distortion of hepatic and thyroid function results. Anoxic damage consumes the hepatic protein elements plus the stored glycogen. These debilitating factors leave a cadaveric organ which is depleted of all its reserve capacity. In this state an additional glycogenolytic process as demanded by thyroid hypermetabolism cannot be satisfied. This is the basis for liver exhaustion and thyroid death.

Experimental evidence on the extraordinary sensitivity of thyroid-fed rats to want of oxygen was recorded by Asher and Duran in 1920.[69] They showed that hyperthyroid animals could not tolerate even minor degrees of anoxia. Two years previously Streuli and Asher[70] found the converse to be true that thyroidectomized rats were able to tolerate a lack of oxygen which brought normal animals to the point of death by asphyxiation.

It has only been recent studies which have revealed the effects of anoxia on the liver in hyperthyroidism. Hepatic distress subsequent to oxygen want is logical. The reason for this is that the liver cells are closer to asphyxiation than other cells of the body because only 25 per cent of their blood supply is arterial.[71] Reinwein and Singer[72] led one to assume that increased oxygen demand by the liver in a hyperthyroid state leaves a narrow vital margin of safety which is easily destroyed. In the same trend of thought McIver[73] has shown that the liver is particularly susceptible to injury under conditions of hyperthyroidism.

More recent experiments by McIver and Winter[74] elucidate the effect of anoxia on the liver during artificial hyperthyroidism in rats. These investigators studied the behavior reaction of the hyperthyroid and of the normal animals when exposed to low atmospheres of oxygen (11 per cent). The normal animals showed no signs of acute distress excepting a slight increase in respiratory rate. The hyperthyroid animals were restless and apathetic. They studied twenty-six rats of which seventeen had received injections of crystalline thyroxine. Nine of the seventeen hyperthyroid rats died after varying periods of anoxia. The first two hours in the low oxygen atmosphere seemed to be the most critical for the hyperthyroid rats.

The effects produced by oxygen lack is one of glycogen imbalance. The studies of McIver confirm some aspects of the work produced by Lewis and his associates.[75] In their studies on the rôle of the adrenal cortex in acute anoxia they confirmed the previous conclusions of Evans.[76,77] All showed that hepatic glycogen tends to fluctuate in rats exposed to low atmospheric pressure.

Knowing *de facto* that a deleterious damage occurs in the liver due to the factors presented, pathological studies have confirmed definite anatomic alterations in the liver. Scholars concerned themselves with this problem as early as 1913. Farrant[78] produced histological changes in the liver by administering thyroxin. Similar results were produced by Gerlei[79] who employed large and even fatal doses of thyroxin. McIver attempted in his experiments to use non-lethal doses, the amount employed was merely sufficient to produce a hyperthyroid state. In this way he hoped to avoid pathological changes in the liver due to overdosage. His plan was to produce alterations in hepatic tissue due to anoxia in hyperthyroid animals. His subjects were all healthy and free from disease. This healthful state of the animals was important because Haban[80] in studying the effects of crystalline thyroxin injections on the liver found tissue change only when some intercurrent infection was present.

The most lucid study on the histological pathology of the liver was made by McIver in his experiments.[75] He has shown that the pathological material from the rats killed after receiving crystalline thyroxin in non-lethal doses failed to reveal any notable histological abnormalities of the liver. However, when the cells were compared

with those of the livers of normal well fed rats, the cells in the livers of thyroxin treated rats were more homogeneous and compact. The appearance of the cells, however, did not differ essentially from the hepatic cells of a starved animal. McIver attributed this analogy to the fact that hepatic glycogen was diminished markedly.

Anoxic changes have been recorded in hyperthyroid rats. As might be expected, the lesions in animals that died or were killed after short exposures to oxygen deficit were not advanced. These changes consisted of fatty changes, vacuolization of the cells and engorgement of the blood vessels. In the animals exposed for longer periods the degenerative changes were severe and widespread.[75] A summation of the pathological findings may be stated as: (1) Necrosis most pronounced around central veins; marked engorgement of the sinusoids especially in the vicinity of the central veins; (2) The cell outlines were often lost. The cells in the areas of degeneration showed an affinity for eosin. Associated with the loss of cell boundaries were found pyknotic nuclei.

From the pathological data already presented the noxious effects of anoxia upon the liver is obvious. It is further evident that in the patient with hyperthyroidism every precaution is essential in order to avoid the complications associated with a low oxygen tension. This problem gives rise to the choice of anesthesia in a toxic thyroid patient who is a potential candidate for anoxic anoxia. For this reason Colcock[81] has stressed this point. Nitrous oxide was abandoned because too little oxygen (usually 10 per cent) was available to the thyroid patient whose oxygen demand was two to three times that of the average patient. Avertin enjoyed popularity and was frequently employed with nitrous oxide. Avertin, a respiratory depressant, has in the experience of Cole and Brunner[82] occasionally increased the toxicity in patients with severe hyperthyroidism. These problems on anesthesia brought to light the rationale and use of oxygen in the postoperative treatment of hyperthyroidism as well as the value of oxygen during thyroidectomy.[83,84]

COMMENTS AND CONCLUSIONS

From the literary review it can be stated that many surgeons and investigators have studied the rôle of the liver in thyroid disease. Of all these, several have intimated and few have definitely incriminated the liver as the seat of distress in thyroid crisis. Our review of this subject leads us to believe that the liver in some way is the organ to be indicted as a potent factor in the pathogenesis of thyroid crisis.

Among the reasons for this belief are: (1) The clinical picture of crisis closely simulates exhaustion resulting from hepatic hyperpyrexia. (2) Experimental evidence and the morbid anatomical findings indicate the close association between hyperthyroidism and the liver. (3) Boyce's results with the Quick hippuric acid test of liver function has been offered as proof of liver damage occurring as the result of thyroid disease. (4) The physiological imbalance and pathological changes in the liver due to anoxemia has been established. Anoxia in hyperthyroidism is common knowledge. (5) The interrelationship between hyperadrenalism, hepatic glycogenolysis and the experimental production of toxic thyroid signs by injections of adrenalin has been emphasized.

The premise of our discussion, therefore, is that the most important organ, exclusive of the thyroid itself, concerned in the production of thyroid crisis is the liver. Physiological failure of this organ will cause so-called thyroid death. This conclusion is reached following clinical observation, experimental data, laboratory function tests and objective findings as revealed by pathological anatomy.

The causative or exciting agents in the production of hepatic imbalance may be multiple or a combination of several. Of all the phases discussed on this aspect of our subject the most plausible possibili-

ties are hyperadrenalism and hepatic anoxia. These states either alone or acting synergistically in the presence of hyperthyroidism may be the fundamental destructive influences in the causation of crisis. Hyperadrenalism may be the activator in depleting the liver of its available glycogen. In this state of insufficiency, the hepatic anoxia resulting from increased hypermetabolism produces the lethal blow which precipitates crisis and the eventual hyperpyrexic thyroid death.

Attention is called especially to anoxia. It is strongly believed that the acute pathological lesions found in the livers of patients dying of hyperthyroidism are the result of anoxia. This is a problem of clinical importance, since the occurrence of anoxia in hyperthyroidism is commonly known. Especially is this of great concern in the production of postoperative crisis, when tracheal obstruction, pulmonary edema or other complications may interfere with adequate pulmonary aeration.

We are not unmindful of the fact that the liver may be merely a solitary reflection of a generalized somatic picture. Anoxemia may affect all the organs in the body in the production of crisis. The liver, however, has been stressed in hyperthyroidism because its normal physiology and pathological physiology can be tested with ease and because this organ is subjected to routine examination at autopsy. That physiological discord in crisis is revealed in other organs and tissues of the body is appreciated. Even though this is known, we believe that the fulminating picture of crisis and death occurs only when the liver has been burdened beyond its ability to compensate for the demands required under the stress and strain of thyrotoxicosis.

On the basis of all the proof offered as to the rôle of the liver in hyperthyroidism, a notation on preoperative preparation is not amiss. Fortification of the liver should be of primary concern. This should include a liberal carbohydrate diet, glucose by mouth, or by vein, and preferably supplemented by decholin, a definite proportion of protein in the diet, oxygen therapy, vitamins and plasma transfusions. In this regard Lahey[17] has stated: "There is one point regarding the treatment of thyroid crises and that is the need to give these patients fluid and glucose constantly and not intermittently. There is a tendency to be intermittent. This is unwise since it leaves periods during which the excessively activated metabolism will still consume the liver reserve. It is necessary in patients with thyroid crises to give them fluids and glucose quite constantly throughout the entire day if one wishes to extricate them from these serious thyroid states."

The topic of preoperative preparation brings to mind the diversity of opinion as to multiple-state operations in thyrotoxic patients. In those patients with toxic goiter, known to be recalcitrant to iodine therapy and considered unfavorable operative risks; surgeons in order to prevent postoperative crisis, have resorted to multiple-stage operations. It is our belief that the beneficial effects of this procedure have not been due to the simplicity of the operation. Credit must be given to the fact that the respite between stages has given the patient a preoperative regimen on more than one occasion. This preparation directed toward "building up the patient" has inadvertently fortified the liver against a future thyroid crisis. In keeping with this thought it is believed that a multiple stage procedure is not the answer to the prevention of crisis, but rather that rehabilitation of the liver is the *sine qua non* of prophylaxis.

One of the purposes of this communication is to bring to the attention of the thyroid surgeon that prophylaxis against thyroid crisis is much preferable to therapy after the syndrome has developed. With this idea before us we have accentuated the value of preoperative rehabilitation of a liver suspected of dysfunction and of fortifying an apparently normal liver. In the preoperative care of patients

suspected of being a candidate for thyroid crisis, we have pursued the following regimé: (1) complete bedrest, (2) lugolization, (3) sedation (phenobarbital, bromides); (4) thiouracil is administered until BMR is normal (0.6 Gm. daily); (5) oxygen tent to combat anoxia and hyperthermia (three days). By placing a patient in a tent an evaluation of the psyche can be estimated. If the patient is perturbed by the tent he is not psychologically prepared for operation. (6) Glucose intravenously plus amino acids and vitamin B_1 (for three days), (7) blood transfusions, (8) cardiac therapy when indicated. It is to be remembered that digitalization in the presence of hyperthyroidism necessitates larger doses of digitalis. The dosage usually increases with the hypermetabolic state. (9) The patient's psyche is strongly considered. The hyperthyroid individual is treated as a psychosomatic entity.

By judiciously adhering to the above regimen we have avoided crisis on the thyroid service at Kings County Hospital during the past two years. The best guides to the patient's response to therapy and calibration as to operability are: (1) The patient's mental attitude, (2) the fall and maintenance of a normal or near normal pulse rate, and (3) a consistent fall and maintenance of a lowered basal metabolic rate. We believe that by stressing the rôle of the liver in crisis, future clinical and laboratory investigators may find the solution to this intricate problem.

In conclusion may we reiterate that clinical observation has suggested a possible hepatic basis for the pathogenesis of thyroid crisis. The physiologist and experimental clinician have presented evidence substantiating this belief. Both gross and microscopic hepatic studies have augmented the proffered evidence. The liver, therefore, when distressed due to glycogen depletion, may be accused as the death producing factor in accelerated hyperthyroidism. By promulgating this concept, it is hoped that interest will be stimulated toward that organ. From this stimulus some future investigator may confirm or deny the master rôle of the liver as the major etiological agent in the production of thyroid crisis.

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FIBROMATOUS SKIN LESIONS PRODUCED BY REPEATED BLOOD SERUM INJECTIONS IN THE HUMAN*

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AT the New Orleans meeting of this group about a year ago, the author described some research[1] which was accomplished with an experimental liver extract which was administered to patients who had developed scars from acne. This paper described a "shrinking" of these scars through the process of vasoconstriction which the experimental material produced. The paper described the same action on keloidal growths.

In a previous communication[2] Rosenthal and Marshall wrote that tissue fluid extravasations might cause the proliferation of fibrous tissue in wounds, since blood serum escaped from the keloids when these were subjected to vasoconstriction through the use of this experimental liver extract.

Furthermore, Marshall and Greenfield[3] showed that tissue fluid extravasations, which follow extensive burns, can be checked by pressure dressings. This has decreased the production of keloids which accompany, at times, the healing processes in extensively burned skin areas.

This paper is intended to outline a theory on the pathogenesis of fibromas and their related structures. Further evidence will be presented which supports this viewpoint.

If scars can be partially shrunk in size with extrusion of inspissated serum, one may be able to introduce serum in normal skin and produce a tumor, for it may be this serum which may be at least partially responsible for fibrous tumor growth.

THEORY OF POSITIVE CHEMOTROPISM FOR FIBROMATOUS GROWTH

Dorland[4] defines chemotropism as "the tendency of cells to turn or move in a certain direction under the influence of chemical stimuli. When the movement is toward the substance exerting the chemical influence, it is termed positive chemotropism; when away from the influence it is negative chemotropism."

The author has noted that Virchow and Cohnheim, and later Nicholas Senn[5] advocated the theory of tumor formation from an embryonic matrix of cells. Much was written about the force which held in check the growth of these embryonic rests. This force was called "physiological resistance." Hence, when the tumor matrix, or embryonic rest, began to grow, it was thought that this physiological resistance was diminished or suspended.

In contrast to the above theory, I wish to offer my theory of positive chemotropism, since the escape of tissue fluids from their normal vessels, such as in the case of blood serum extravasations, seems to exert a definite chemotropic response. This inspissated tissue fluid seems to have the ability to attract fibroblasts. These cells infiltrate such areas which contain this foreign matter of blood serum, and in the course of time, these fibroblasts, as you well know, form scar tissue. The rapidity of this fibromatous growth may depend, among other properties, on its location and whether or not it happens to be sealed by an epidermal covering. If the growth encounters relatively loosely woven or firm structures, these may enhance or confine its growth.

As Moore has stated,[6] "There is no sharp line of distinction between hyperplasia of connective tissue in repair and neoplasia of fibroblasts; hence there are a number of conditions which resemble fibromas but which should not be so

* This paper was read for the author by Dr. Alfred W. Harris, of Dallas, Texas, before the Southern Section of the American Federation of Clinical Research in that city on February 2, 1945.

designated. Some use the term 'pseudo-neoplasms' for them."

The Present Experiments. In order to test the author's theory of positive chemotropism in fibroblastic growth, it was deemed advisable to simulate the production of tissue extravasation with injected serum. This would necessitate repeated small injections of blood serum, which at their best, could not duplicate the delicate natural mechanism of diapedesis in the living tissue spaces. As my former teacher Christopher aptly puts it:[7] "The lymph of the exudate is derived from the blood, and represents an outflow so great that the lymphatics are unable to cope with it, so that it accumulates in the tissues. The amount of the lymph depends partly on the nature of the tissue (open or dense) in which the exudate occurs. In some forms of inflammation it forms the bulk of the exudate, e.g., in the sting of an insect."

The purpose, then, of the present experiments was to introduce blood serum repeatedly into normal skin tissues in order to determine whether or not a chemotropic influence could be exerted upon fibroblasts so that they would be attracted to the site of injury and begin the laying down of scar tissue. If this could be accomplished, an entirely new view might be given to the pathogenesis of benign neoplasms such as fibromas, desmoids, keloids, morphea, and other related tumor masses. Furthermore, if one could produce fibromatous growths at will, additional information would be available as to their prevention.

Luetagin Injections on Author. In order to test the theory of positive chemotropism, which the author supports, blood serum from a "Wassermann-fast" case was used. Although this blood serum was at least three years old, it was preserved with ½ per cent phenol and was deemed to be in good condition and certainly not injurious, since it had been subjected previously to several measures which rendered it non-infectious. This material had been employed in a series of experiments for skin-testing normal and syphilitic patients[8] and I employed this material for my own injections since I had no equipment at the time to process the serum from myself. This serum was called "luetagin" since it was prepared from a syphilitic case.

The right thigh of the author received $\frac{2}{10}$ cc. of luetagin, given intracutaneously, while the left thigh received the same amount of saline (physiological). Both materials contained ½ per cent phenol as a preservative. Thoroughly aseptic methods were followed rigidly to avoid infection. The injections began February 24, 1944, and were repeated in the identical areas on February 25, 29, March 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12 and 13. Then no further injections were performed. Both areas were observed daily. A definite small tumor mass was continually observed in the experimental site, while the control area remained negative. On May 14, 1944, under aseptic surgical technic, and with novocaine anesthesia, both the control and experimental areas were extirpated by myself, placed in separate labelled glass vials, which contained 10 per cent formalin. These were mailed to Dr. Rosenthal, Milwaukee, Wisconsin, for examination.

Pathological Report. No fibromatous changes were noted in the control block of tissue. The experimental site contained a small section of tissue which had undergone fibrosis. Microphotographs and lantern slides of both the control and experimental sites have been prepared by Dr. Rosenthal. (Figs. 1 and 2.)

The pathologist's report is as follows: "*Luetagin Experiment:* Sections taken from the control and test areas and stained with hematoxylin and eosin revealed no change in the epithelium of either area. However, in the subepithelial tissue definite differences can be detected. The text area exhibiting condensation and thickening of collagen material in the subepithelial tissue was further confirmed by Masson trichrome stains."

The Second Series of Injections in the Human. Instead of employing luetagin, as in the first set of injections on the author,

it was deemed highly advisable to prepare the blood serum directly from the author's blood. Hence, 20 cc. were withdrawn by infiltration. Each section was again placed in separate vials which contained 10 per cent formalin as a preservative. These were

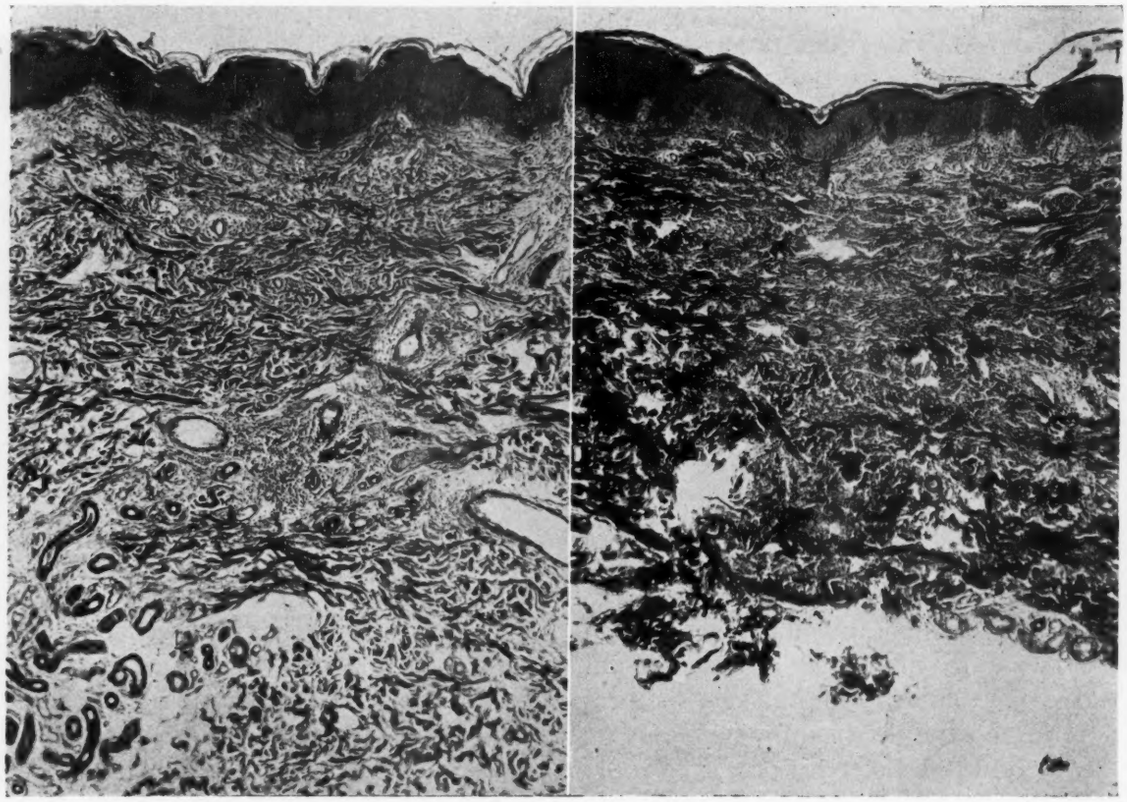

FIG. 1. (Control.) FIG. 2. (Tumor.)

FIGS. 1 AND 2. Luetagin experiment. Note Figure 2 (tumor section) showing condensation and thickening of collagen material in the sub-epithelial tissue with obscuring of the capillaries. Changes not seen in Figure 1 (control section).

the author, and the blood serum was preserved with ½ per cent phenol in rubber-capped vials. Again, aseptic technic was employed throughout the procedures.

On January 8, 1945, the author began serum and control (saline) injections of $^{2}/_{10}$ cc. in opposite portions of the thigh two inches above the original sites of extirpations. Again, both the experimental (serum) and the control (physiological saline) solutions each contained ½ per cent phenol as a preservative. From the above date through January 17, 1945, the author administered fourteen sets of injections (control and experimental). On January 20, 1945, both sites were removed by the writer under aseptic surgical conditions with the use of a novocaine sent again to Dr. Rosenthal for pathological studies.

It should be reported that the experimental site bled much more freely than did the control site when the injection areas were extirpated. I take it that the blood supply was increased at the site of the tumor mass.

Pathologist's Report. As in the first sets of sections, the control area was normal while the experimental area contained a larger area of fibromatous tissue than was noted in the tissue which was treated with luetagin. Photomicrographs and lantern slides have been prepared from these tissues by Dr. Rosenthal. (Figs. 3 and 4.)

The pathologist's report is quoted as follows: *Human Serum Experiment (Author):*

Sections taken from the control and test areas of skin reveal no changes in the epithelium in either instance. In the

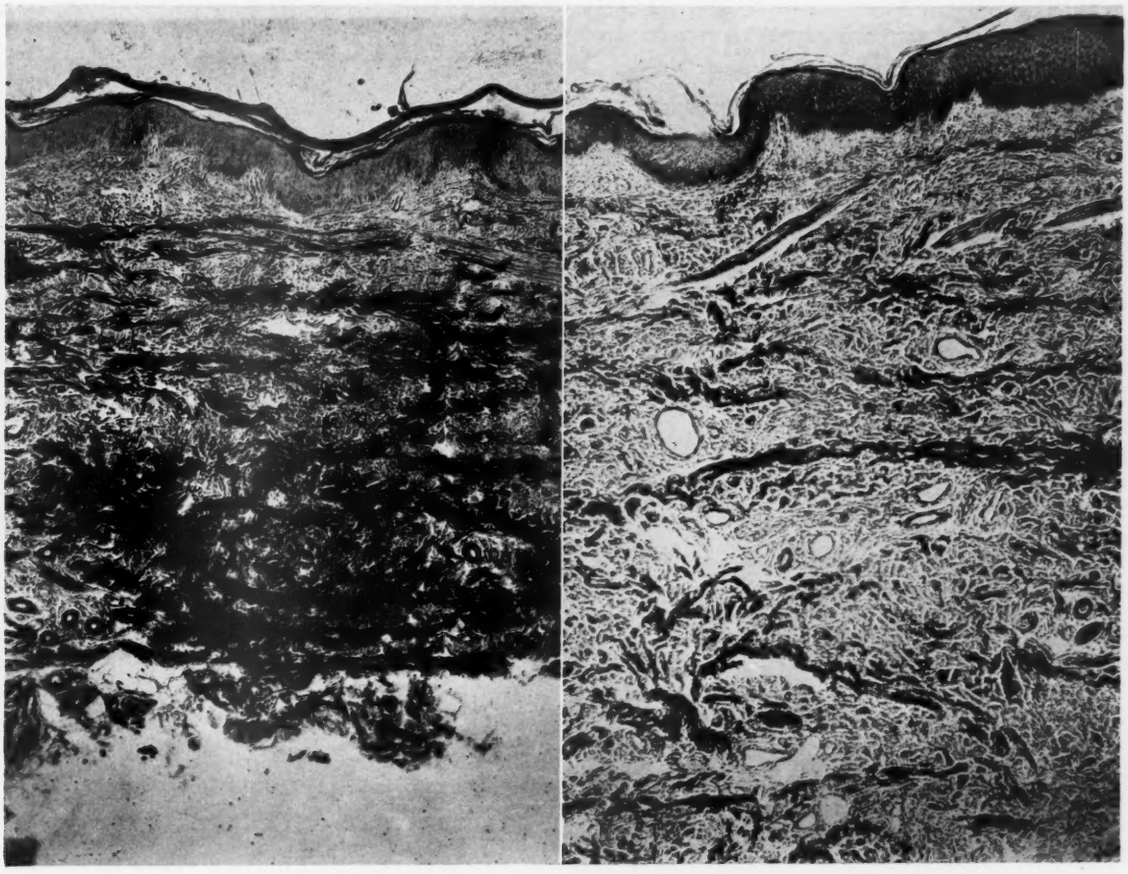

FIG. 3. (Tumor.) FIG. 4. (Control.)

FIGS. 3 AND 4. Experiment with author's blood serum. Note Figure 3 (tumor section) showing pronounced condensation increase and thickening of sub-epithelial collagen material with thickening of capillaries and diminution in number. Changes not seen in Figure 4 (control section).

subepithelial tissue the test area, however, shows changes not seen in the control area. The changes consist of very marked thickening, condensation and marked increase of collagen material. In addition, there is diminution in the number of capillaries and thickening of their walls. These changes are much more pronounced in the human serum tissues than they are in the tissues injected with Luetagin. The nature of the condensed material in the subepithelial tissue was further confirmed by Masson trichrome stains.

Changes seen are similar to those found in early human keloids.

COMMENTS

From the experimental findings, it appears that repeated injections of blood serum have the ability to attract fibroblasts. This supports the author's theory of active chemotropism in the pathogenesis of fibromatous tumors. To the writer's knowledge, this constitutes the first series of experiments which have produced such tumors from blood serum alone.

The fact that tissue plasma is so abundant in burned areas, which are notorious for their ability to develop hyperplastic scars and keloids, leads us to the opinion that the elimination of this swelling of the tissue spaces by compression, in such injuries, is a sound therapeutic measure.

Professor R. A. Moore, of Washington University Medical school,[9] has observed

an extensive fibrous mediastinitis in a negro male at autopsy. This further points to massive exudations of serum in the mediastinum which may have exerted a positive chemotropic action on fibroblasts with the consequent laying down of fibrous deposits in such an area. This view is supported further by the case reports of Hamman and Rich[10] who, among other findings, reported an extensive, diffuse and progressive interstitial proliferation of fibrous tissue throughout all lobes of both lungs. They reported that the cause of the disease was unknown; but with our present findings, it does not seem too absurd to think that a massive exudation of blood serum occurred in these patients which may well have produced the fibrotic changes in these lungs.

Furthermore, it does not seem impossible to visualize the formation of hypertrophic scars and keloids from our experimental findings. If fibromas of the skin are related to hypertrophic scars, at least pathologically, and the empiric distinction is made between hypertrophied scars and keloids, in that these scars are excessive productions of fibrous tissue within the limits of the wound, while the latter is exactly the same process plus a similar invasion of the surrounding skin,[11] it appears to the author that all of these pathological processes may have a similar pathogenesis. It may well be that the concept of active chemotropism may aid future research in such conditions. At any rate, the above research can be repeated easily by those who wish to observe and study the formation of these

TABLE I
SCHEDULES OF INJECTIONS ON AUTHOR WITH LUETAGIN

Date	Amt. of Luetagin Cc.	Amt. of Saline (Control) Cc.	Observations
2-24-44	0.2	0.2	
2-25-44	0.2	0.2	
2-26-44	0.2	0.2	
2-28-44	0.2	0.2	Persistent induration noted in exp. area
2-29-44	0.2	0.2	Induration persists in exp. area
3-1-44	0.2	0.2	
3-2-44	0.2	0.2	
3-3-44	0.2	0.2	Definite soreness over exp. area, induration does not disappear; control area negative
3-4-44	0.2	0.2	
3-5-44	0.2	0.2	
3-6-44	0.2	0.2	
3-7-44	0.2	0.2	No soreness in exp. area to injection; felt definite resistance to needle; control area negative
3-8-44	0.2	0.2	
3-9-44	0.2	0.2	
3-10-44	0.2	0.2	Both areas bleed freely following injections
3-11-44	0.2	0.2	
3-13-44	0.2	0.2	

Seventeen injections administered in each area. 5-14-44: Both areas extirpated by author under local anesthesia. Experimental area appeared more vascular during surgery than did control area.

TABLE II
SCHEDULES OF INJECTIONS WITH AUTHOR'S BLOOD SERUM

Date	Hour	Amt. of Serum Cc.	Amt. of Saline (Control) Cc.	Observations
1-8-45	12:20 P.M.	0.2	0.2	Experimental injection more painful
1-8-45	3:05 P.M.	0.2	0.2	Serum not so painful this time
1-8-45	5:00 P.M.	0.2	0.2	
1-9-45	3:30 P.M.	0.2	0.2	Definite induration persisted since last injection at experimental site
1-10-45	1:45 P.M.	0.2	0.2	Exp. area became painful 30 seconds after injection; induration in experimental area persists; control area negative
1-10-45	4:45 P.M.	0.2	0.2	Neither injection painful
1-11-45	10:00 A.M.	0.2	0.2	
1-11-45	4:10 P.M.	0.2	0.2	
1-12-45	10:00 A.M.	0.2	0.2	Stinging at exp. site about 30 sec. following injection; exp. site continually indurated; control negative
1-13-45	12:00 A.M.	0.2	0.2	Exp. area bleeds following injection
1-15-45	1:30 P.M.	0.2	0.2	
1-16-45	11:30 A.M.	0.2	0.2	
1-16-45	3:55 P.M.	0.2	0.2	Fluid escaped at sites of both injections; needle met with resistance at exp. site, control negative
1-17-45	2:00 P.M.	0.2	0.2	Redness over exp. area

Fourteen injections administered in each area. 1-20-45: Both areas extirpated by author under local anesthetic. Experimental area appeared much more vascular and indurated than control area.

fibromas for themselves. It would be well to remove these tumors at regular intervals in order to study these changes in relation to the time factor. The author has not been able to induce his nurses, nor patients to submit to such studies. It is hoped that other medical colleagues will not meet with such sales resistance.

SUMMARY

The basic work, which led to the author's concept of positive chemotropism, is reviewed. Tissue fluid extravasations seem to attract fibroblasts, which actively lay down connective tissue, when blood serum is injected into normal skin tissue. The author does not favor the concept of tissue rests which have been thought to form neoplasms. Rather, it is evident that blood serum has the property to attract fibroblasts which may form fibromas when blood serum invades the cell spaces of skin.

The author has described two sets of experiments. The first employed serum taken from a "Wassermann-fast" case. Although this particular serum was three years old, it led to the formation of a small fibromatous lesion when this serum was injected intradermally repeatedly. The control site, which received similar amounts of saline, remained negative.

Serum taken from the author and injected repeatedly intracutaneously, caused the formation of a larger fibromatous area than did the three-year old serum taken from the luetic case. The control site, which received similar saline injections, remained negative.

Microscopic evidence has been obtained which shows that subepithelial changes similar to those seen in keloids can be produced experimentally by the injection of serum into the subepithelial tissues.

The fact that the experimental sites, after six days, opened wide after the sutures were removed, points to a widespread injury of the adjacent tissue not involved by the tumors. This was not evident in the control areas. Further work is being done on this subject by Dr. Rosenthal, and at a later date, he may be able to present some pertinent information as to why these experimental areas were so delayed in healing and why they bled so profusely during extirpation of the tissues.

The author is grateful to Dr. Samuel Rosenthal, of Marquette University Medical School, Milwaukee, Wisconsin, for the pathological studies which he performed for this research.

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DISSECTING ANEURYSM OF THE THORACIC AORTA DUE TO TRAUMA

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THE pathological condition known as *aneurysm* is, by definition, an abnormal, circumscribed, blood-containing cavity communicating with an artery. Classification upon the basis of gross anatomy can be made with a minimum of controversy by a simple scheme which has apparently been acceptable since presented by Herschfelter:[4] (1) True aneurysms, (a) sacculated, (b) fusiform; (2) dissecting aneurysms; (3) false aneurysms; (4) arteriovenous aneurysms; (5) cirsoid aneurysms.

These various types may occur in almost any artery but there is obviously a greater likelihood in certain localities as is indicated by figures compiled from a series of 530 aneurysms discovered at autopsy as quoted by Ridge:[8]

Thoracic aorta	175
Popliteal artery	137
Femoral artery	66
Abdominal aorta	59
Carotid artery	25
Subclavian artery	23
Axillary artery	18
External iliac artery	9
Cerebral artery	7
Common iliac artery	2
Posterior tibial artery	2
Gluteal artery	2
Pulmonary artery	2
Brachial artery	1
Subscapular artery	1
Ophthalmic artery	1

More recent reviews of the subject would undoubtedly add several more locations to the list and alter the proportions but it is certain that the incidence of aneurysm would still be greatest in the thoracic aorta.

The location of any aneurysm is determined largely by its etiology. It can be assumed that those of traumatic origin will appear most frequently in the exposed superficial vessels, while from the fact that syphilis attacks the thoracic aorta most actively, aneurysms from that cause would almost always be found in the mediastinum. Since aneurysms of the aorta are disorders of a large artery which is well protected from outside influences, it is to be expected that the development of an aneurysm in this location will usually be due to intrinsic arterial wall damage either from degeneration or disease. Tabulations bear out this reasoning and it has been estimated that 90 per cent of all aortic aneurysms are due to syphilis.[8] A summary of the distribution of types of aortic aneurysms may be obtained from an analysis of figures collected by Riffin[9] from the literature and from the post-morten records of the Massachusetts General Hospital. A rearranged tabulation of his figures is as follows:

Number of autopsies analyzed				9600
Number of aortic aneurysms found				116
Types:				
True dissecting aneurysms				17
Small "dissections" around plaques				13
True aneurysms:				
Ascending aorta	21			
Aortic arch	37	Total thoracic	66	
Descending aorta	8			86
Abdominal aorta	20			
Etiology:				
Thoracic aneurysms	Syphilitic			60
	Arteriosclerotic			3
	"Senile ectasia"			3
Abdominal aneurysms	Syphilitic			3
	Arteriosclerotic			17

DISSECTING ANEURYSMS

The above figures appear to cover the entire question of aortic aneurysm but there is a notable lack of attention paid to the group designated as *dissecting aneurysms*. Elsewhere in the literature this matter has been discussed[1,2,3,6,7,10] and the

"spontaneous" development of dissecting aneurysms has been explained upon the basis of defective arterial walls and abnormal hydrostatic pressures.[6] It has been stated that the underlying factor is degeneration of the middle coat and that artheroma is not a common cause. Dissecting aneurysms are almost never seen to start in the abdominal part of the aorta where the grossest artheromatous ulcers are found.[2] Syphilis plays little or no part[10] but senile dilatation without arteriosclerosis has been emphasized.[9] Once the microscopic damage has been done the lesion begins as a penetration of the circulating blood into the substance of the wall of the vessel with subsequent extension of the effused blood for a varying distance between the layers. The sac thus formed communicates with the original lumen of the artery at the point where the intima was first ruptured and after extending to its limit, the new space may become thrombosed, may break again into the original lumen of the artery or, more commonly, may rupture into an adjacent space such as the pericardium or the pleural cavity.

The partial rupture of the aortic wall and the formation of a dissecting aneurysm may, however, develop in a healthy aorta if the causative factor in the form of trauma is severe enough.[10] This last situation is undoubtedly one of the rare forms of a rare condition and Samson,[10] discussing this condition in 1931, stated that only "about a hundred" cases had been reported up to that time (1895 to 1931). Additional examples of traumatic dissecting aneurysm of the thoracic aorta have been mentioned from time to time in American medical publications with a vagueness that defies analysis.[7,10] The impression one obtains is that the proof of the traumatic etiology is usually somewhat presumptive and that the development of the dissecting aneurysm is considered to have been due to some remote trauma in the absence of evidence of any alternate cause.

In view of the fact that dissecting aortic aneurysms caused by trauma are rare and that the evidence of the traumatic etilogy is usually unsatisfactory, it has seemed worth while to present with this discussion the history of a patient who entered the Mary McClellan Hospital in November, 1944, as a routine automobile accident casualty with injuries which were thought to be obvious. Like so many cases of dissecting aneurysm, his condition was not recognized before death,—probably entirely due to the fact that this diagnosis was not considered. In the literature the record of anti-mortem diagnosis is so poor that McGreachy,[6] in 1937, was bold enough to say that of the 500 cases of all types of dissecting aortic aneurysm on record only nine had been recognized before autopsy. This author made a point of reporting three more which had been recognized before death and other authors have followed suit by reporting their successes with just pride. The diagnosis can, therefore, be made in many cases of spontaneous dissecting aneurysm once the differentiation between coronary thrombosis,[1,12] perforated peptic ulcer and acute pleurisy has been made, but it will be seen that when the dissecting aneurysm is the result of recent trauma, the distinguishing symptoms may be completely masked by the ordinary evidences of the accident itself.

CASE REPORT

The patient, a sixty-year-old man, weighing 150 pounds, was admitted to the hospital less than twelve hours after an automobile accident. Looking back into his hospital record it was found that official information began in 1932 when he was forty-five years of age. At that time he reported having had severe influenza in 1918 and two rib fractures, the latest in 1932. There were no complaints relative to the cardiorespiratory system but a story of chronic (fifteen years) digestive disturbances led to his being admitted to the hospital in 1932 for study. As a result of examinations a diagnosis of chronic cholecystitis had been made on the basis of *x*-ray studies of the gallbladder while a gastrointestinal *x*-ray series demonstrated a normal stomach and duodenum. The routine examination of his heart showed no enlarge-

ment, murmurs, or thrills and the rate and rhythm were stated as being normal. The blood pressure was 124/74.

The patient was not again seen until June, 1940, when he reported with an infected finger for which he was again admitted to the hospital. On the record of this admission mention was again made of the chronic stomach distress and intermittent right upper quadrant abdominal pain. The presence of dyspnea, palpitation or chest pain was specifically denied and the heart and lungs were normal to examination. The blood pressure was 158/78 and the blood Wassermann reaction was negative (June 1940).

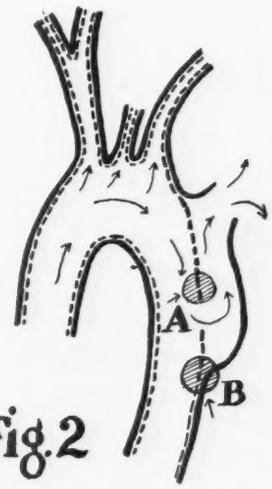
At the time of the present admission the patient brought his past history up to date by reporting the loss of two fingers from the right hand by gunshot injury three years before, a "nervous breakdown" one year before and an infection of the right leg six months before. His family contributed the information that he had never been troubled with dyspnea, palpitation, chest pain or cough and that he had worked energetically on the highway until the winter lay-off a few weeks before. They also stated that he was temperate both in the use of alcohol and tobacco.

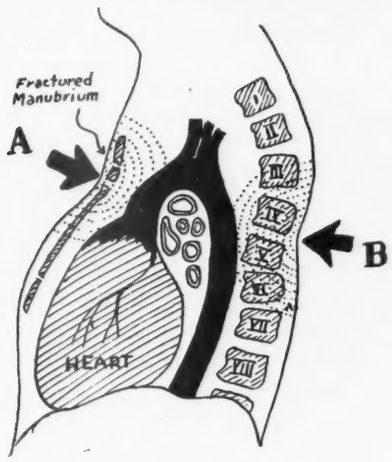
The accident which caused his final admission to the hospital occurred while the patient was driving his own car in complete possession of his faculties and in perfect health. A collision of three automobiles took place and the patient was pinned between the steering wheel and the back of the driver's seat so that considerable difficulty was encountered in extricating him from the wreckage. In the process he was heard to complain bitterly of a severe pain in the anterior region of his chest as well as in the region above his left knee where deformity and abnormal mobility indicated a fracture. He was taken to a nearby hospital where a Thomas splint with fixed traction was adjusted and he was then transferred in a few hours to the Mary McClellan Hospital. Examination showed some superficial skin abrasions on the anterior wall of his chest with sufficient underlying pain to restrict breathing and indicate that trauma had been received on the left anterior chest wall extensive enough to have caused at least a contusion of the tissues of the thoracic cage. There was also an epigastric distress as an extension of the pain in the chest and the presence of a comminuted fracture of the left femur was verified by *x*-ray. The patient's blood pressure was 150/70.

During the patient's first three days in the hospital he ran a temperature and developed the familiar picture of accumulated bronchial secretions so often associated with the pain-inhibited respiratory movements of an injured chest. Bronchopneumonia was feared and sulfathiazole given. It was repeatedly apparent that the patient breathed with difficulty when flat, and for partial relief, his head was elevated as much as the restrictions of the fracture apparatus would allow. Two readjustments of the fracture were made after the initial fever had subsided, each time with spinal anesthesia. On the first occasion the blood pressure was noted as 122/90 (November 10th) and the second time as 140/80 (November 18th). After November 10th, the fractured member was suspended from an overhead frame and a trapeze provided so that with his arms the patient was able to lift his shoulders and hips for the routines of bed care. The fact that he could do this encouraged the belief that the injury to the chest was not very extensive.

The patient remained with treatment directed primarily toward the reduction and maintenance of the fractured bone for fifteen days. The chest pain eased on the fourth day but the cough on exertion and the orthopnea persisted without evidence of the gradual improvement experience would lead one to expect from injury as serious as a rib fracture. Otherwise there was nothing which could have given warning of the impending dramatic death.

During the early part of the day of his death the patient appeared as usual. An effective routine enema had been given in the morning but at about 4 P.M. there was a rather unexpected and urgent desire to defecate. Inasmuch as the patient was at that moment in conversation with the author, he joked about this unexpected activity and demonstrated complete good humor as the bed curtains were drawn and he proceeded to have a satisfactory bowel movement. Without again opening the curtains the nurse began the routine evening care which involved the usual rolling from side to side in which the patient helped himself by lifting with both of his hands on the overhead trapeze provided for him. This routine finished, he was preparing to use the mouth wash when he was observed to lose color





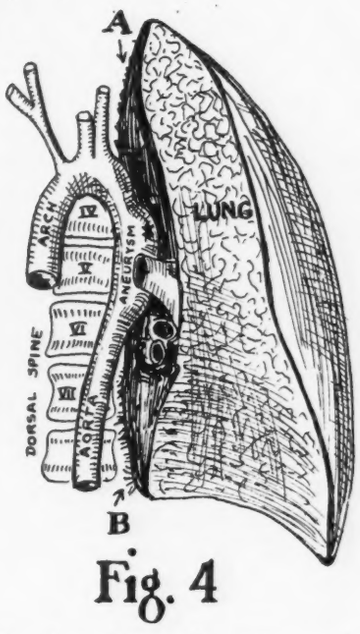


FIG. 1. Heart and aortic arch showing location of dissecting aneurysm in the first part of the descending aorta. Through the point of secondary rupture (marked by arrows) blood was pumped directly into the left pleural cavity to cause sudden death fifteen days after automobile accident.

FIG. 2. Schematic longitudinal section through the aortic arch showing the media as a broken line and the adventitia as a solid line. These two layers have been separated by the dissection of the aneurysm and the points of primary and secondary rupture are as indicated. Microscopic sections taken at points "A" and "B." (Figs. 5 and 6.)

FIG. 3. Diagrammatic median sagittal section through the thorax to show the mechanism of distortion due to squeezing forces "A" and "B" which caused fracture of the manubrium and injury to the aorta.

FIG. 4. Sketch to show the relationship between the aneurysm of the aorta and the neighboring dorsal spine. Pleural adhesions found along the posterior margin of the left lung are indicated between points "A" and "B."

suddenly. His motions were instantly arrested and consciousness faded with a rapidity so startling that no clue was ever obtained as to it covered the vertebral bodies. (Fig. 4 A–B.) Beneath the parietal pleura along this same line there seemed to be a discoloration due to

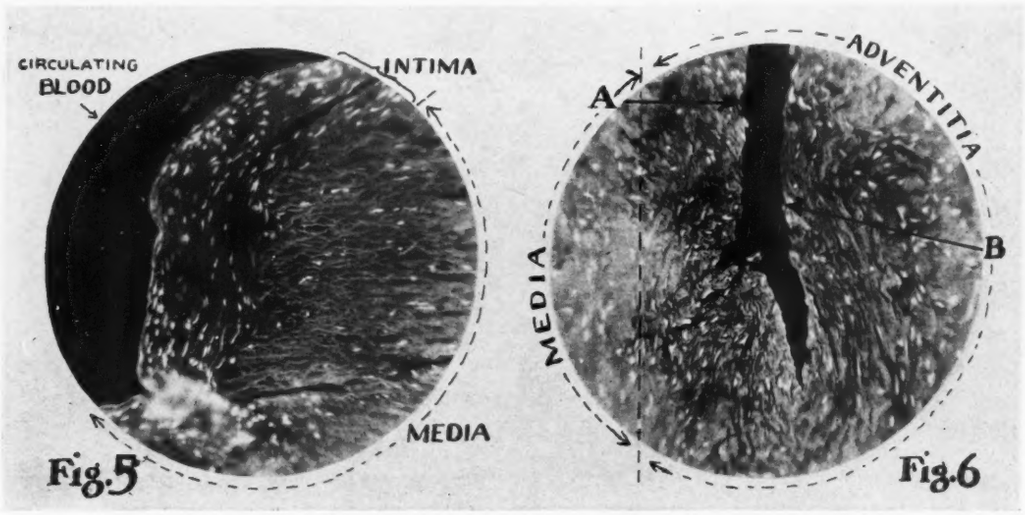


FIG. 5. Microphotograph of the arterial wall at the point of primary rupture. (Fig. 2 "A.") Elastic tissue of the media has been sharply broken without evidence of previous degeneration. Retraction of these fibers and probably some proliferation of the intima has covered these ends. (Note: A negative print of the enlargement has been used to accentuate the structural elements. Dark area to the left may be considered the cavity of the aneurysm filled with blood.)

FIG. 6. Negative print of a microphotograph at the point where separation is progressing. (Fig. 2 "B.") Dissecting blood space appears black and the separation of the layers is seen to be advancing through the adventitia close to its junction with the media. There is no degeneration or tissue reaction near the split and the cavity of the aneurysm shows no intimal lining either on the side toward the lumen of the aorta (A) or toward the outer layers of adventitia (B).

what sensations he may have experienced. His breathing came to a complete stop after a few seconds of jerky chest movements and in the time it took to get a stethescope into action his heart had stopped beating. Some adrenalin was injected hurriedly into what should have been his pericardium but proved to be entirely futile and death was pronounced in less than two minutes after the start of the spell.

An autopsy was done about four hours after death in order to clarify the relationship of his death to the automobile accident. The most significant findings were those in the thorax which was opened in the usual manner by removal of the sternum and costal cartilages, demonstrating in the process that a hitherto unsuspected transverse fracture through the manubrium was present. The left pleural cavity was found to be filled with blood clot compressing the left lung almost completely and pushing the heart and mediastinum to the right well beyond the midline. A further clarification of the situation disclosed a line of fresh adhesions fixing the entire posterior border of the left lung from apex to base to the parietal pleura where extravasated blood extending from the region of the thoracic vertebral bodies downward for a short distance below the diaphragm. After clearing the clot from the left thoracic cavity it was found that the bleeding had not come from any chest wall injury but had escaped from an irregular opening in the upper mediastinal pleura where further exploration demonstrated a dissecting aneurysm of the first part of the descending aorta at a point adjacent to the body of the fourth dorsal vertebrum. (Figs. 1 and 4.) The capacity of this aneurysm was estimated as having been about 50 cc. and the dissection had encircled the aorta for about two-thirds of its circumference on the left and anterior aspects. The pericardium, heart valves and blood vessels were grossly normal. The abdomen showed no significant disorder and, interesting enough, the gallbladder and bile ducts were also normal. Specimens were removed for microscopic examination.

The pathologist described the specimen of the aneurysm as a piece of the descending aorta whose lining showed wrinkling and artheromatous changes without definite calcification.

On the convex side the media was described as having been dissected away from the adventitia and the cavity produced partly lined with fibrin and a small amount of blood clot. Sections were obtained from the artery at the point where the dissection was advancing and from the media at the margin of the original rupture. (Fig. 2.) A complete description of the histology is presented in the legends for Figures 5 and 6.

COMMENT

It is believed that, to a unique degree, the circumstances of this case present proof that a dissecting aneurysm of an essentially normal aorta can be caused by transmitted trauma. There must be, in a physical sense, a very fine difference in the amount and direction of forces which will in one case tear completely through the aorta and produce instantaneous death and in another case split only the inner coat to start the development of a dissecting aneurysm whose eventual fatal rupture is delayed. It may be admitted that any such event as a partial rupture of the inner coat would be more likely to happen from trauma in an aorta already diseased or degenerated so as to be on the verge of spontaneous rupture. It is perhaps for this reason that experienced physicians universally express a desire for proof that trauma and trauma alone can bring it about. The rôle of trauma in the production of dissecting aneurysms of the aorta seems to be mentioned in every text book discussion of the subject of aneurysms but a sensitive reader can feel the scepticism in the author's words as he strives to make his account academically complete by some such phrase as, "Trauma must be mentioned on a account of the peculiar cases in which rupture due to trauma is not accompanied by any external marks or even by fracture of the ribs or other injury,"[5] or "The location of the lesion suggests that the aorta might have been previously damaged by syphilis in spite of the negative blood Wassermann reaction."[7]

It might be well to repeat some of the observations made by Samson[10] who seems to have been one of the few to concentrate seriously upon the matter of traumatic dissecting aneurysms of the aorta. His statements published nearly fifteen years ago are interesting in comparison with observations made in the case history herewith reported and the close agreement of the two provides evidence that the entity is still appearing as it did in his day. Speaking of dissecting aneurysms in general, Samson repeated the opinion that syphilis was a rare cause of the condition although it might be seen in a small number of cases as a coincidental finding. Samson also remarks that traumatic aneurysms of the aorta are practically all dissecting and while relatively more rare than the spontaneous type, they would be seen more frequently because of the increased number of industrial and automobile accidents. These generalizations fit our case but inspection of medical references does not seem to indicate that the condition is being reported with any greater frequency. Samson adds that traumatic dissecting aneurysm may occur in a healthy aorta and that the aneurysm is generally formed at the time of the accident or immediately following. He lists severe blows on the chest by large, blunt forces and crushing chest injuries with fractured ribs as causes of the initial rupture of the inner layer of the aortic wall. With all this our case also agrees. Samson points out that the commonest location for the first injury is just above the aortic valves and tries to indicate that due to the presence of the ligamentum arteriosum, the posterior wall of the aorta is at this point relatively more fixed so that it may be crushed against the vertebral column to receive the brunt of any impact. In our case the rupture would not appear to have depended upon any such anatomical factor; severe local injury apparently came from the nature and direction of the force itself.

In the case which we have reported the circumstances of the accident and the regions showing evidence of tissue damage

present unquestionable proof that the trauma was a squeezing of the thoracic cage between an anterior force represented by the steering wheel of the patient's car and a force from behind represented by the back of his seat. (Fig. 3.) The force from the front (Fig. 3A) caused a sharp depression which resulted in a transverse fracture of the manubrium at a point directly anterior to the aortic arch. The other force from behind (Fig. 3B) caused a broader pressure giving probably a local hyperextension with some tearing of the anterior longitudinal ligaments of the spine in the region of the fourth dorsal vertebrum against which the first part of the descending aorta lay. There may have been a sudden flattening or angulation of that vessel so that at that point the initial rupture of the intima occurred as a direct result of the trauma. Traumatic inflammation of the neighboring pleural surfaces would account for the adhesions along the posterior border of the left lung.

During the course of this man's illness certain symptoms were evident which, in retrospect, can be recognized as those of the dissecting aortic aneurysm. A tearing pain referred to the anterior chest and a certain degree of shock were both characteristic[1,2,3,6,11,12] but were indistinguishable from the same symptoms which might have been entirely due to the trauma itself. The cough and dyspnea on exertion together with the orthopnea were less characteristic of chest trauma and should perhaps have been the clues to the real diagnosis. The quiescent period of relative comfort after the first shock is known to occur in cases of dissecting aneurysm but the absence of progressive improvement beyond this point should have suggested that something other than uncomplicated chest trauma was back of it. Finally, the dramatic death came, and if the possibility of dissecting aneurysm had been considered, this would have settled the point conclusively. Somehow the diagnosis of pulmonary embolism seems to be the first to enter the minds of the startled attendants when death comes thus suddenly, but a second thought would show many obvious differences. It is hoped that this report of a well authenticated case of traumatic dissecting eneurysm of the thoracic aorta will provide stimulus for that second thought.

In conclusion it might as well be noted that the prognosis in dissecting aortic aneurysm is bad whatever the cause. Samson[10] estimated that 65 per cent die instantly and that about 15 per cent more died suddenly in the next few days. The small number that survived probably developed a "healed aneurysm" by virtue of a blood clot or a rupture back into the original lumen of the aorta. East[2] repeated the calculation that 80 per cent of the patients die in the first few days. Taking this bad prognosis into consideration it becomes important not to mistake a dissecting aneurysm of the aorta for coronary thrombosis, perforated peptic ulcer or acute pleurisy even in the absence of external injury and to entertain, as a result of this faulty diagnosis, any ideas about surgical treatment or hope for the relatively favorable prospects of these other conditions.

SUMMARY

A brief review of the subject of dissecting aneurysms of the aorta due to trauma has been presented as a result of interest aroused by the postmortem diagnosis of a case following death from injuries received in an automobile accident. From the fact that the rôle of trauma in the production of aneurysms of the aortic arch is so incompletely discussed in medical literature, it is concluded that the condition is a rare variety of a relatively rare pathological entity and that complete clinical facts of such a case will therefore be of interest. That this fatal condition may be present after an automobile accident even when the aorta was previously normal becomes an important consideration for any physician who handles such accidents and who

may at any time be involved in the resulting litigation.

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A deficient circulation of blood accompanies some arterio-venous aneurysms; the results include general weakness of the limb, early fatigue on exertion, and perhaps swelling and pain when the limb is dependent—symptoms which resemble those following closure of the main venous channels. A special and noteworthy feature is the speed with which the swelling disappears after elevation of the affected part.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

THE USE OF WHOLE SKIN GRAFTS AS A SUBSTITUTE FOR FASCIAL SUTURES IN THE TREATMENT OF HERNIAS*

PRELIMINARY REPORT

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BRIGADIER EDWARDS,[1] in the British Journal of Surgery, has exposed in masterly fashion the modern views on the treatment of inguinal hernia.

The position is that the Bassini operation, with all its modifications, is not only inefficient, but actually harmful, and should be abandoned. In its stead there are two alternatives, each with its indications. The first, or physiological, in which a simple herniotomy with high excision of the sac is combined with repair of the torn or weakened fascia transversalis, and the second, or plastic, in which living fascial sutures are used to narrow the internal abdominal ring, and to strengthen the weakened posterior wall of the inguinal triangle. One is in full accord with the view that a study of the history of hernias is recommended to all who have been, or may be persuaded into designing and perfecting a new method of cure for this age-old deformity; and one further agrees that improvement will come, not from the evolution of more operations, but from careful attention to technic, pre- and post-operative care, selection of the most suitable method of repair for each case, and increase in the technical skill of the operator. Despite that, the author believes that in the method to be described here there is a promise of good results.

Edwards' paper should be read as a background to this, which is distinctly a preliminary report suggesting that the use of whole skin grafts inlaid under extreme tension and in such a fashion as to protect the posterior wall of the inguinal canal, and narrow the internal ring, may be superior to fascia in most respects. The method has been used for cases in which fascia was formerly indicated, and a history of the investigations which have been in progress in Aberdeen during the past year will be detailed.

First, however, it is necessary to discuss the position which the use of fascia holds, and to note its advantages and disadvantages. Thus it may become clear that there is room for further improvement, and therein lies the justification for suggesting a new method.

USE OF FASCIA IN HERNIAS

McArthur, in 1901, introduced the use of living fascial sutures for repair of inguinal hernias, but since that time the method has not been so extensively accepted as it deserves, and comparatively few surgeons have adopted it as a routine measure. McArthur utilized strips cut from the aponeurosis of the external oblique muscle, and applied them following the principles of Bassini or Halstead.

In 1910, Kirschner[2] developed the technic, and used strips of fascia, or a plaque of fascia lata, cut from the thigh. Since then the only outstanding contribution has been made by Gallie and LeMesurier[3] who further advanced Kirschner's method and published their work in 1921.

Gallie and LeMesurier threaded strips of fascia lata through special needles and interwove them between the conjoined tendon and Poupart's ligament. They showed that the fascia excited no inflammatory reaction, that it survived for many years, united with the tissue in which

* From the Woodend-Oldmill Hospitals, Aberdeen, Scotland.

it was embedded, and, owing to its great tensile strength did not stretch under pressure as does ordinary scar tissue. The use of the special needle folded the fascia into rounded cords which, in the course of a few weeks became surrounded by a film of vascular areolar tissue. From this film, septae of similar tissue penetrated the spaces between the folds and into the adjacent structures, to effect firm union, and form a dense plaque of firm fibrous tissue.

At the end of three weeks any individual fascial cord had the appearance on section of a structure closely resembling that of normal tendon.

In 1940, McCloskey and Lehman,[4] and also Joyce,[5] attempted to stimulate further interest in the use of fascia, and emphasized that it should not be reserved exclusively for very large and very difficult hernias, but should be used for all in which a repair other than the physiological type was indicated. Joyce advocated it for all primary direct and indirect inguinals, all femoral, and for all types of recurrent, also umbilical and ventral. This is going somewhat too far, because, as Edwards and many others have emphasized, where the abdominal rings are not dilated, where the muscles have retained satisfactory tonus, where the canal has not been stretched, and where the patient is young and healthy, by far the best results are obtained by high excision of the sac, and repair of the transversalis fascia combined with re-education of the muscles at an early stage in the postoperative period.

The indications for the use of fascial sutures are: (1) All recurrent herniae of any type; (2) all primary direct inguinals; (3) all primary oblique inguinals, where there is muscle atrophy and weakness of rings and posterior wall; (4) all funicular or "saddle bag" types; (5) as the final stage in the Mayo repair of umbilicals, and (6) as the final step in repair of large ventral or incisional hernias.

It is thus recognized that fascia is reserved for those cases which are most likely to recur, and in those subjects whose physique is prejudicial to the success of a physiological repair. It might then be expected that cases dealt with by fascia would show the higher recurrence rate.

Recurrence Rates. Follow up recurrence figures show very wide variation in different clinics, in the same clinic with different surgeons, and are influenced by many variable factors. An optimistic and self-deceiving eye may discount a small painless bulge over the scar, where the critical analyst would accept it as an early failure. Figures based upon questionnaires are reliable only up to a point. In my own series, most of the patients were examined personally by myself, and were also asked the questions of a questionnaire sent to others. The difference between facts, and the patients' opinions was striking. Twenty per cent of all those with recurrence were unaware of the fact. This is a common experience in most clinics.

Despite the difficulties attendant upon acceptance of published figures, certain facts emerge clear. The recurrence rate varies in the case of indirect inguinal hernia, up to 30 per cent with an accepted average of 12 per cent. Max Page,[6] in a series analysed in 1934, found that there was a recurrence rate of 20.5 per cent as against 12 per cent in 1942. The reason for the improvement lay in the adoption of more conservative methods of treatment in the earlier type of case.

McCloskey and Lehman[4] analyzed the the results in different American Clinics, and found that with Bassini operation and its modifications, recurrences varied from between 5 and 20 per cent for the indirect types and between 7 and 42 per cent for the directs.

When fascia had been used, recurrences varied in different clinics from 3 to 4 per cent for the indirect, and between 7 and 9 per cent for the direct varieties. These figures are representative of extremes found in a number of different clinics, but it is clear that the use of fascia, though it

be in the less favorable type of case, definitely reduces the incidence of recurrence.

Much depends upon the time interval before re-examination. It is accepted that at least 75 per cent recur within the first year, and at least 60 per cent within the first six months.[6–9]

When allowance has been made for variable factors, fascia still emerges from the test as being the best available method for those patients who require repair. The results are good, and one may be asked what valid reason there is for attempting to use other substances.

Disadvantages of Fascia. Fascia does have certain disadvantages. These will be briefly indicated:

1. The McArthur method does not give enough fascia to fulfil the requirements of the average case, and is applicable mainly to the inguinal type. For a large hernia the method is not ideal.

2. The Gallie technic involves either an extensive wound in the thigh, or a small incision combined with the use of a fasciotome. In either case there is a risk of postoperative pain referred to the thigh and hip joint of the affected side, and the possibility of obvious muscle hernia. This pain may be quite intractable and last for many years. It is aggravated by exercise, and, in my experience occurs in 25 per cent of subjects, though to a widely varying degree, and in none is it so severe that life is made intolerable for the sufferer, nor does he desire another operation for its relief.

The etiology of this pain is obscure, and is not necessarily due to muscle hernia, because it is not always cured by repair of this condition. The pain has a definite bearing upon the use of fascia, and in those cases of hernia in which a workman's compensation suit is impending, or in Service personnel, may be a great annoyance.

3. Infection of the wound in the abdomen is more common after this method of herniorrhaphy than by others. Bendick[10] found sepsis to be present in 7.9 per cent of his cases in which autogenous fascia had been used, and in 12.1 per cent in which ox fascia was used. Beekman and Sullivan[11] admit the increased liability of sepsis in fascial operations owing to the increased operating time necessary for their performance. In my own series of 120 fascial repairs mild sepsis developed in five, and moderate sepsis in two. In one, healing was delayed till the thirty-fourth day, but all the others were healed with twenty-two days.

4. There is also an increased liability to develop postoperative pulmonary complications, owing, it is considered, partly to the increased operating time, and partly to another factor. Churchill and McNeil[12] investigated the reduction in vital capacity following upon abdominal operations, and found that it varied with different types of operation and of incision. They established that there is a relationship between the incidence of pulmonary complications for a particular type of incision or operation, and the reduction in vital capacity associated with that procedure. Where there is plastic repair and reflex muscle spasm, the reduction in vital capacity is the more marked. In simple herniotomy this is considerably greater. The relative incidences of postoperative "chests" is in accord with this finding.

5. Fascia will unite to fascia under considerable tension[13] and it may be applied under tension to unite the conjoined tendon to Poupart's ligament, or, it may be darned loosely between the two structures. In either case there are potential gaps between the strands of fascia, and not always do all the strands unite with one another. Potential gaps exist, and recurrences, as in the case of Bassini, develop mainly in the form of the direct type.

In the patients with recurrences operated upon by myself after previous fascial repair, with one exception the sacs have been of the direct variety, and found close to the medial aspect of the canal. In several, the sac had clearly insinuated its way through a gap in the fascial strands which in other parts had effected a powerful reinforcement.

6. The needle used for the Gallie method is large, and apt to traumatize the inguinal ligament. The significance of this is obscure, but an impression exists that it may predispose to formation of direct or femoral recurrences.

There is also an appreciable risk of penetrating the femoral vein. This complication has been frequently mentioned in the literature,[14] and has occurred, I am confident, on many more occasions than have been reported. This may be an extremely difficult hemorrhage to control, and in one which came to my notice, death resulted on the operating table.

7. Finally, there remains a substantial recurrence rate, and the figures quoted above may be regarded as the best available. Even there, the figure for the direct variety is too high, and in the hands of many surgeons the figures are considerably higher for both types. It will surely be admitted by all that even the best figures available are still too high, and provide room for consideration as to how they may further be reduced.

In an attempt to overcome the risks of sepsis, Koontz,[15] Rosenblatt and Meyers,[16] Jalifier,[17] and Christophe[18] have all investigated the possibilities of using dead fascia which has been sterilized. Were such fascia proven to be effective, time would be saved during the operations and postoperative sepsis and "chests" would probably be fewer. The thigh incisions with their associated late pain and muscle hernia would be avoided.

A great deal of research has been done by these and other workers, but the method has not yet become popular, though it seems to be becoming more so in America. Nevertheless, the technic evolved does not affect the recurrence rates.

In conclusion it may be stated that fascia has been of great value in the treatment of direct and large hernias, that it is becoming more extensively used for those patients who formerly would have been given a modified Bassini repair, but that though the method has reduced recurrence there is still room for further improvement. Finally, there is an associated higher incidence of postoperative sepsis and chest trouble, and the residual pain in the thigh which may affect a proportion of the subjects is a disability of significance.

CUTIS GRAFT REPAIR

Rehn[19] and Loewe[20] advocated the use of a method known to them as the "cutis graft method for the repair of anatomical defects in postoperative herniae," and of these, Rehn was the first to apply the principle clinically. The term "cutis" was coined because, though derived from the skin, it is not a true skin graft, being defective in epidermis. Cutis contains all the elements of the skin excepting the epidermis, it is elastic, inherently active, and composed of a rich network of connective tissue fibers. After transplantation, according to Uihlein,[21] these inherent factors persist in the metamorphosis of the graft, and, owing to the stimulus initiated and maintained by the tension under which the graft is sutured, a metaplasia into stout connective tissue takes place.

Rehn and Schwartz, quoted by Uihlein,[21] performed a tenotomy of the tendo Achilles in a dog, and repaired the defect with cutis graft. They found that a gradual metamorphosis took place after ten weeks, into a tendon, difficult to differentiate from ordinary tendon. When the experiment was repeated with fascia, regeneration was slower, and repair less complete.

Eitel[22] showed quite conclusively that cutis lives longer, is more active than fascia, and is thus more suitable for plastic repair. He removed pieces of human fascia and cutis at operation, and performed metabolic studies upon them by the Warburg technic. His findings demonstrated the superior viability of cutis over fascia, and he determined that this fact held good for both sexes and for all age groups.

Rehn applied his cutis graft, which he took from the thigh, into the defect

Fig. 1.

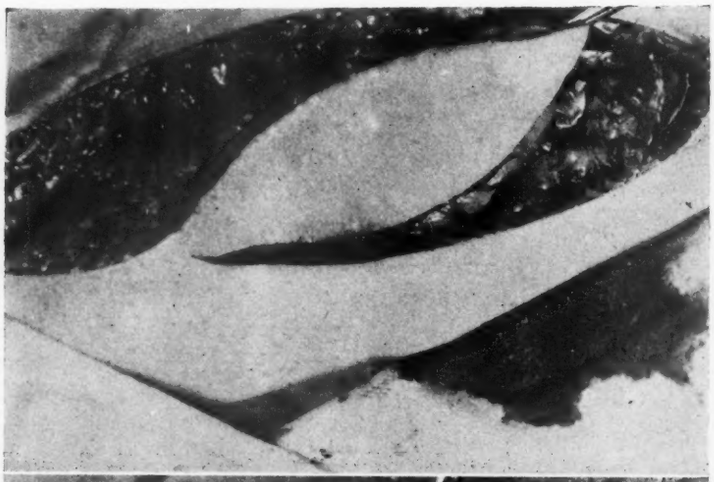

Fig. 2.

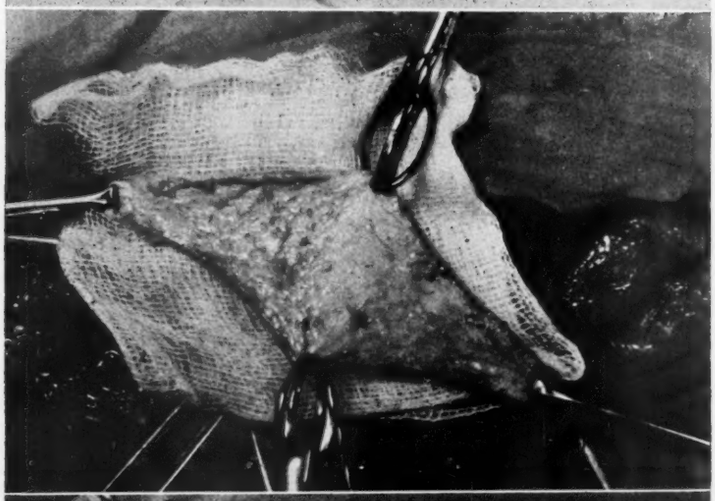

Fig. 3.

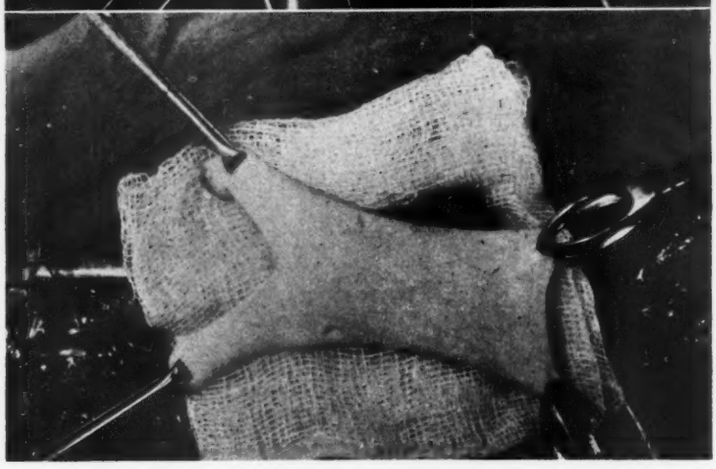

Fig. 1. The incision has almost been completed and the ellipse is ready to be freed and lifted out.

Fig. 2. The graft is shown fatty side upward and ready for preparation.

Fig. 3. The graft has been prepared and shaped. It is shown with the superficial surface upward.

requiring plastic repair, and attached it under a maximum degree of tension to its surrounding structures by interrupted sutures. The graft was cleared so far as possible of epidermis.

Fig. 4.

Fig. 5.

Fig. 4. The graft has been anchored medially. The two tails of skin held by forceps embrace the internal ring.

Fig. 5. The graft has been sutured into position, and the two skin pedicles approximated lateral to the internal ring. The new ring formed of skin is clearly shown overlying the muscular one deeply.

Uihlein was afforded the opportunity of operating upon two patients who had submitted to a cutis graft repair four years earlier. Sections were removed for examination. He found that there was a complete metamorphosis of the transplant. The grafts represented normal connective tissue with its fibrous and fatty components, blood vessels and nerves. No hair follicles or glandular tissue could be identified, and there was no evidence of cyst formation, either macro- or microscopic. He did, however, note the presence of large cells with clear deeply staining nuclei and lying in rows or in rings. These were interpreted as being remains of hair follicles or glands, surrounded by giant cells, macrophages and lymphocytes. No scar tissue was seen in the sections examined.

Rehn used this method in sixty-five gross postoperative hernias with six poor late results. There were a further thirty-nine operations in which cutis was used to fill in a tissue defect, and of the total of 104 operations for various purposes, fifteen were complicated by wound sepsis.

Cannaday[23] has described his experiences with cutis repairs in two contributions to the literature. He and his surgical associates in the Charleston General Hospital used the method in thirty-seven cases, of which twenty-seven were hernias of various types. Two operations were followed by mild sepsis and two by small hematomas. But these workers warmly applaud the principle, and state that it is superior to fascia. They find that the graft heals firmly and promptly, and commend the fact that it is easily obtainable in portions as large as necessary for any given case.

Neither Cannady and his co-workers, or Rehn and his associates have investigated with detail the histology of their grafts, but they are agreed that clinically the results are excellent. A good deal of work has been done by others in regard to cutis implants, though here they were not sutured under tension, but merely embedded into the body tissues. It may be that the different methods adopted to use the graft may be associated with variations in the histological findings. This question will be discussed later, but, for the moment it is necessary to consider the findings of these plastic surgeons who have studied the histology of cutis implants, remembering that these were buried grafts, but not sutured under tension.

Eitner,[24] and Peer and Paddock[25] have studied the subject at length. They found that despite every attempt to remove the epidermis, apices of hair follicles and sweat glands were still to be found in the grafts, and that when implanted, these structures disappeared and the grafts were gradually transformed into fibrous tissue. They found that the grafts fused with their surroundings through the mechanism of inflammation and repair associated with aseptic wound healing.

Peer[26] conducted a detailed investigation into the fate of cutis implants in a large series of nasal reconstruction operations. He stored pieces of derma with cartilage beneath the skin for periods up to two years, and studied sections prepared from these at varying intervals. He observed a gradual degeneration of the normal skin structures, with disappearance of hair follicles and sweat glands at an early stage. These were replaced by fibrous tissue. The investigations raised the old question as to the danger of epidermoid cyst formation; and as this is an objection which is frequently raised to the use of cutis implants, it is well at this stage to consider it thoroughly.

Garre[27] made the observation that implantation of epidermis alone produced a smooth-walled cyst, whilst in the cyst rising from a dermal implant skin papillae were present in the wall. The comb of a cockerel has no hair follicles or glandular structures, and was thus selected as the object of an experiment by Kaufmann[28] in 1884. An elliptical incision into the comb was made and the edges of the wound closed over the enclosed ellipse of tissue. A cyst was formed, and it is evident that this could not have arisen from other than epidermal elements.

In the same year Schweninger[29] performed a similar experiment in a dog, producing a subcutaneous cyst. This type of cyst was found to contain in its lumen, cholesterol, epidermal scales and fat, while in the walls were found hairs and sebaceous glands.

Hesse[30] and Pels-Leusden[31] both produced implantation cysts by means of a foreign body embedded beneath the dermis, and both investigators agreed that the origin of the cyst was from glandular epithelium injured by the skin incision, and not related to the implantation of epidermal cells. These cysts contained all the layers of normal epidermis but no dermal elements.

Zimches[32] buried free strips of whole thickness skin into the muscles of dogs and studied the implants up to two years. His conclusions may be summarized: (1) The epidermis of the implant curves upwards in a U shape, the margins of the U meeting during the fourth week to form a

closed cavity lined with epithelium. (2) The cyst continues to grow because the lining epithelium constantly produces cornified cells which are shed into the lumen. Part of the content is made up of epithelial débris and broken down hairs. (3) Secondary cysts may develop from hair follicles. (4) The implanted section of skin heals in its new bed and rapidly fuses with its surroundings by means of granulation tissue later organized into tough fibrous tissue. (5) No metaplasia of epithelium was noted, and no malignancy observed at any stage.

From all of these and other experiments performed in animals, considerable argument can be developed against the method. In the human subject, however, the work of Peer and Paddock[25] opened up new avenues of consideration, and when combined with the clinical experience of Rehn, Cannaday and their associates, suggest that the method is entirely safe, and that the risk of later epidermoid cyst formation is remote. There is, however, as indicated above, a difference between merely laying in a cutis graft in a prepared bed, and suturing it to its attachments under as great a degree of tension as possible. Moreover, the pieces of cutis studied by Peer and Paddock were small by comparison with the sizes of graft required for many hernias, and it is reasonable to suppose that these two factors may modify the histology. The indications from Uihlein's two cases are that metaplasia follows much more rapidly where tension has been applied to the graft and that it is much more complete.

The method adopted by Rehn has clinically one decided disadvantage. The prepared thigh has an area of epidermis removed from it by a Thiersh razor, and from this denuded part the cutis graft is cut. The edges of the resulting wound are devoid of epidermis and are closed as well as possible. Yet healing is slow and, in any case, time is lost in the preparation of the graft.

The question arose in the author's mind as to whether it was really necessary to remove the epidermis, and with that end in view he investigated the use of whole skin implants sutured under tension in rabbits and in guinea pigs. At the same time the operation has been applied clinically to a considerable number of hernias in which fascia otherwise would have been used. The results to date will be fully detailed.

WHOLE SKIN GRAFT IMPLANTS

In 1938, the author was confronted with the problem of closing and repairing a very large ventral hernia in a woman, aged sixty-four. For the first time he implanted a large whole skin graft, having excised and closed the redundant peritoneum. The graft was sutured to the anterior aspects of both rectus sheaths, and to the medial aponeurotic expansions of the external obliques. The graft measured some four inches by five inches, and was taken from redundant skin excised by an elliptical skin incision. The repair was firm and satisfactory. Eighteen months later there was no recurrence or other complication. Between 1938 and October 1943, a similar method of repair was adopted in seven large ventral, three umbilical, and one epigastric hernia. In none was there any complication during the postoperative period but, unfortunately owing to the War situation and the resultant migrations of myself and the population, none of the cases was followed up for more than a few months. The immediate results, however, had been so encouraging, that it was determined to apply the same method to the repair of inguinal hernias, and to investigate the histology of the implants.

Histology of Grafts Applied to Rabbits and Guinea Pigs. The rabbit was chosen as being a suitable animal for the work. An incision was made over the lumbar vertebral spines, the lumbodorsal fascia exposed and a portion excised. The defect was repaired by a whole skin graft cut from the edges of the wound, and sutured

under a high degree of tension to the adjacent aponeurosis. Two types were used: In the first, the hair was clipped away from the graft, but a coating of some 3 mm. in length was retained as a challenge to Nature's ability to deal with such a type of foreign body. In the second, the hair was removed as completely as possible, but the epidermis in both cases was undisturbed. Sections of normal rabbit skin were studied for comparative purposes. Sections examined were stained with hematoxylin and eosin, with Van Giesen's connective tissue stain and with Weigert's elastic tissue stain.

It was found that in the first group, in which the grafts had a coating of fine hair, in sections examined five months later, while sebaceous glands, hair follicles and epidermis had entirely disappeared, hairs had been surrounded by a massive foreign body reaction, and this in turn was being encapsulated off by a firm fibrous stroma. Macroscopically, at five months it was very difficult to determine the margin of the graft, this being so firmly attached to its surroundings, and so closely resembling dense normal fascia in appearance. The degree of metaplasia was striking.

Microscopically, however, dermal elements could be identified apart from the hair remnants. Atrophied sweat glands were detected, and a few dermal papillae in a similar state of degeneration. The dermis showed a dense infiltration with fibrous tissue and impressive degree of vascularity. The margins of the graft were firmly united to adjacent fibrous tissue, and vascular septae infiltrated deeply from the graft to subjacent muscle. A number of small rounded, and encapsulated structures were noted which appeared to be masses of cornified epithelium arranged in whorls.

In the second type of case in which the graft had been carefully shaved of hair, but in which epidermis had not been damaged, reaction was similar in essentials, but foreign body response was less intense. The grafts were all intensely vascular, hair follicles could not be identified, sebaceous glands and dermal papillae were absent, and sweat glands were showing signs of advanced atrophy and fibrous tissue replacement.

In sections studied after three weeks the graft had materially altered macroscopically, and closely resembled white fibrous tissue. Microscopically, all elements of the skin could be identified, but a fibroblastic reaction was in process, and granulation tissue was apparent at the margins of the implant.

No trace of epidermoid cyst could be detected, and the epidermal tendency to elevate in U shape to form a cyst as described by Zimches[32] was absent. Instead, the epidermis was being desquamated and the cells and débris removed by phagocytes.

Sections removed at other stages showed features intermittent between the two extremes described.

Similar experiments were conducted in a number of guinea pigs. None of the animals survived for more than five days, but, in the sections examined, early infiltration with new blood vessels and round cells was noted and also commencing atrophy of hair follicles, with phagocytosis of epidermal débris and hairs.

The opportunity arose to explore an inguinal canal in the human subject, into which a whole skin graft had been sutured for a large direct hernia three months earlier. A Kodachrome color film was taken of the exposed canal, and it is hoped to be able to publish this in my next contribution on the subject. The graft was very firmly attached to Poupart's ligament, aponeurotic medial aspect of the internal oblique, and insertion of rectus sheath in the pubis. It was not possible to identify with assurance where the graft ended and normal tissues began, as the change into tissue closely resembling that to which the implant was sutured was so striking. The appearance closely approached that of a normal inguinal canal, and the dense fibrous tissue formation and

deformity of normal anatomy, which is so striking a feature of recurrent fascial hernias, was absent. It is difficult to imagine wherein the repair could have been improved. A section of the superolateral part of the graft was removed for examination. The histology was that of highly vascular connective tissue, in which no dermal or epidermal elements could be identified. The graft was richly infiltrated with collagen fibers, and there was firm adhesion to the underlying muscle. No trace of even microscopic cyst formation was found, but a number of giant cells were observed. No hair remnants could be identified.

The animal experiments are being continued, and in a later report the findings will be submitted. Let it suffice for the moment to say that sections have been examined at intervals up to ten months after implantation of the grafts in rabbits, and that the findings closely coincide with those of Peer and Paddock[25] in relation to cutis grafts. No contraindication to the use of the grafts in the human subject has been found by this method to date.

Clinical Application of the Principle. In a series of 119 inguinal hernias, direct, indirect and recurrent, six umbilical, ten ventral, one epigastric and one femoral, repair has been performed by means of a whole skin graft. There have been two cases of mild sepsis which have cleared up, the first under three weeks and the second under four. One scrotal hematoma developed and there have been twelve cases of postoperative bronchitis, which cleared up within a few days.

The results have been satisfactory but, of course, much more time must elapse before recurrence figures can be submitted. So far as late postoperative complications are concerned there have been none so far, but these will be considered at a later date when more time has elapsed and more cases are available for analysis.

Table I

Type of Hernia	No.	Average Age
Indirect inguinal	80	45
Recurrent indirect inguinal	2	27.5
Direct inguinal	28	43
Indirect-direct	9	48.5
Umbilical	5	44.0
Recurrent umbilical	1	55.0
Ventral	10	39.9
Epigastric	1	38
Femoral	1	39

Table II

COMPLICATIONS

Sepsis	2 cases, cleared 21 to 28 days
Chests	7 cases bronchitis, mild
Others	1 scrotal hematoma, cleared.

TECHNIC OF OPERATION

Skin Preparation. This is highly important. It is suggested that the skin chosen for the purpose, coming as it does from the vicinity of the symphysis pubis, is potentially infected, and that even if the surface be sterile, organisms may lurk in the depths of the hair follicles. Proof of the safety of using this skin lies in the results of experience. The method has been used in 137 cases with impunity.

The method of skin preparation is first of all by careful shaving followed by scrubbing with ether soap and warm water for ten minutes. Spirit compresses and a sterile double hip spica bandage are then applied. The procedure is repeated daily for three days in all.

Before operation, in most of my cases, a culture of organisms from the skin was taken. Only a few showed any growth, and these mainly scanty colonies of Staphylococci albus.

Anesthetic. The anesthetic of choice, is, in my view, gas oxygen and ether with preliminary premedication of omnopon and scopolamine ¾ cc. Local anesthesia is perfectly suitable, and I have done a few with it. The disadvantage is that it is essential for this operation that the muscles be completely relaxed, otherwise, when the graft is in position and apparently under tension, further muscle relaxation reduces this tension, and vitiates the

entire principle of the technic. For ideal relaxation an inhalation anesthetic is essential. The exponents of spinal anesthesia may use it if they desire.

Incision. This is elliptical, the superior limb starting over the symphysis pubis, and curving upward with the concavity downward, toward the anterior superior spine for a distance of three and a half to four inches. The inferior limb commences over the external abdominal ring at the first incision, and extends upward and in a lateral direction with a slight downward convexity. These incisions are fashioned to enclose an ellipse of skin which is at least two inches long, and approximately one inch wide at the broadest diameter.

The skin with attached subcutaneous tissue is removed, and immersed in warm normal saline solution until required.

The external oblique is incised in the usual way and the flaps reflected to expose the inguinal canal and spermatic cord. The superior flap of the aponeurosis is detached for a distance of approximately one-half inch from its pubic connection, in order the better to expose the area to which the graft will be sutured medially. This having been done, the cord with cremaster muscle is lifted from the canal, and both are separated clearly from the floor and from adhesion to the inguinal ligament from the internal ring to the pubic end. It is essential to clear the area thoroughly, and this is readily done by clean firm sweeps with a gauze swab.[33]

The cremaster and coverings of the cord are incised in the usual way, the sac dissected clear, and removed by ligation and excision at as high a level as possible. In this connection it is sound to follow the method of Miller,[34] or ensure high ligation by rotating the structure and transfixing it just distal to the deep epigastric vessels. The sac must always be transfixed, and never merely ligated as the risk of such a ligature slipping is very real. In most old or large hernias there is an area of constriction or scar tissue on the peritoneum of the sac. This is firmly adherent to the adjacent cord; and if it is considered to be the true neck, and ligation performed at that level, the risk of recurrence is increased, as the apex of the stump is bound to the cord outside the internal ring, and its retraction is restricted.[35] This fibrous attachment must be freed and it must be ensured that the freed stump will retract to as high a level as possible. It is ill advisable to suture the stump to the anterior abdominal wall as it causes necrosis of muscle fibers bound into the anchoring suture, and prevents high retraction of the stump.[36] Absorbable gut should be used for the purpose.

The next step is to buttress the fascia transversalis, and to narrow the pillars of the internal ring by carefully inserted sutures. The importance of the fascia transversalis can hardly be over emphasized. In earlier days the importance attached by Bassini to the conjoined tendon tended to remove attention from this important fascia, but, in actual point of fact Bassini himself made much of the step, and it is his pupils rather who overlooked it. Wyllis Andrews[37] visited Bassini's clinic and described the technic as practiced during his visit. He made it clear that the first deep suture of Bassini, included the transversalis fascia in order to narrow the internal ring. In even earlier days, Cooper and Scarpa[38] clearly understood the significance of this fascial layer and brought out the fact in a textbook on the subject. When this line of sutures has been inserted, a firm support for the graft is fashioned, and internal ring is narrowed, and an added protection against later direct recurrence provided.

The repair of the incision in the coverings of the cord is made with a running suture and attention turned to the graft.

The ellipse of skin will be found to have shrunk considerably in size. The extremities are seized by Allis forceps and the subcutaneous fat rapidly dissected away. The pointed extremities of the ellipse are then chopped off, so as to leave a free end of at least one-third of one inch at one end,

and one-quarter at the other. The larger end is then incised vertically along from its mid-point for a distance of approximately one-half to three-quarters of an inch, and each tail of skin grasped at its tip by an Allis forcep. The whole is then laid into the inguinal canal and the inferior forcep placed below the retracted cord. The forceps are then pulled upward and laterally so that the apex of the v thus formed grips the internal ring.

The medial margin of the graft is sutured by three stitches, to the lower anterior aspect of the rectus sheath, the fascia over the symphysis pubis, and the extreme medial edge of Poupart's ligament. Care is taken that the graft is stretched taut and that it well overlaps the pubis and rectus.

The superior Allis forceps is then drawn gently but firmly upward and laterally to stretch the superior edge of the graft tightly. The end of the skin pedicle is then sutured to the medial aponeurotic expansion of the internal oblique. The lower skin pedicle is then also drawn outward and the extremity sutured to the shelving inner margin of Poupart's ligament at least one-half inch above the level of the internal ring. Sutures are placed at intervals of about one-quarter of an inch along the lower edge of the graft to anchor it to Poupart's ligament, and care is taken that the ligament is sutured as near the floor of the canal as possible. The final row is applied to the superior edge of the graft, and fixes it to the aponeurotic medial edge of the internal oblique very close to the lateral margin of the rectus sheath.

The outer aspect of the graft is then sutured, joining the two pedicles together lateral to the internal ring, and in such a fashion as to form a skin plaque lateral to it as well as medial, forming another ring of skin over the internal muscular ring, and causing the cord to arch slightly upward in its course from the ring to the canal.

In inserting the superior row of sutures, and those joining the two skin pedicles, care is taken to ensure that the graft is sutured under great tension to its attachments. When they have been inserted, the skin is white and blenched, tightly drawn over the floor of the canal, and in close apposition to the buttressed fascia transversalis with no dead space between.

Thirty-day chromicized catgut is used for suturing the graft. In my experience linen is inferior to catgut for most purposes, and this is the experience of many surgeons. Longacre[39] and Maingot[40] adopt a contrary view, and the subject is open to discussion.

A fine layer of sulfonamide powder is insufflated on to the surface of the graft and the surrounding tissues, the external oblique is closed, a running suture applied to the fascia of Scarpa and Camper and the skin sutured with interrupted fine silk gut.

The closed incision is angled like a hockey stick medially, and this hockey stick type of incision has found favor with several workers.[41,42] It is reputed to be kept more readily free from infection, to facilitate dressing, and to be more comfortable from the patient's point of view.

Finally, a hip spica bandage is applied with the hips slightly flexed and in the position of physiological relaxation of the inguinal muscles, as so often advocated by Lyle.[43]

Sutures are removed on the eighth day, movements are allowed in bed after the fourteenth, and the patient is allowed up on the twentieth day. It is established that fascia requires three weeks to heal firmly, and there can be no point in permitting freedom of movement before that day. There are sufficient recurrences without adding to the already numerous risks.

In this description of technic, no mention has been made of the many difficulties which may confront the operator; lipomas in the canal, the "saddle bag" type of hernia, where there are both direct and indirect in the same subject, grossly atrophied musculature, the complete congenital scrotal or sliding varieties, and so forth. The intention has been to describe

the application of the method to a straightforward type of case. But, it is emphasized, that as the whole skin graft is advocated for use in large and difficult cases, it follows that difficulties will be encountered, and they are all readily capable of being surmounted by this new method.

The same principles can be adopted for direct hernias, and can easily be used as a final reinforcement for umbilicals, ventral or epigastrics, and in fact, one of the main attractions is the general applicability of this method to any type of hernia.

COMMENT ON THE OPERATION

It must be recognized that a certain amount of experience with the method is necessary before mastering the technic. So far as duration of operation is concerned, in my first seven or eight cases my time was generally fifty minutes. Since then it has become less, and for the last fifty I have rarely required over one-half hour to perform any variety of primary inguinal herniorrhaphy. Recurrents of course, may take somewhat longer.

It must be emphasized again that when the graft has been sutured into position it must be as taut as possible. When correctly bestowed it affords protection to the entire inguinal canal, and narrows the internal ring. In regard to this latter point, care must be taken not to narrow it too much lest later varicocele or testicular atrophy develop. The apex of the v in the graft should fit snugly into the muscle of the internal ring on its inferior aspect, and and cord should emerge smoothly but with a slightly altered direction, from the ring over the edge of the skin graft into the canal.

In preparing the bed for the graft it is essential to withdraw the cord and cremaster intact as far medially as possible, and to retract skin and loose areolar or fatty tissue at the medial extremity of the wound, so as to obtain a thoroughly good view of the area on the dorsum of the symphysis and the lower margin of the rectus abdominis. It is to this area that the graft will be sutured and it must be adequately exposed. If attention is given to these points, the graft will give protection to the medial margin of the canal where a direct hernia is so prone to develop, and a stout reinforcement of the entire posterior wall of the canal will be effected.

In my experience the operation takes less time to perform than a fascial repair, and the finished immediate result appeals to me as being stronger than that presented by fascia. In very large cases a second layer of skin can be superimposed on the first.

There is never any difficulty in obtaining closure of the skin wound even after removal of the graft. There is always sufficient loose skin in the area to provide a large enough portion for use in repair.

The rationale of the procedure is sound. Skin and connective tissue are sutured to connective tissue.

There is not space in this communication to deal with the question as to feasibility of union between muscle and fascia or between conjoined tendon and Poupart's ligament. This has been thoroughly investigated, and the weight of evidence is overwhelming in demonstrating that any union which may take place is poor and of little value as a method of repair.[44–48] In the case of the skin graft, union should and does take place with great strength, because the underlying principle is sound. Care must be taken, however, to ensure that all fatty tissue is cleared from the area of operation, that there is no bleeding, and that any dead space between the graft and its bed is minimal in amount.

Finally, my impressions to date are that the method is superior to any other with which I am familiar, and that postoperative complications are fewer than when fascia is used. It is too early to give figures of recurrence or late postoperative morbidity, and it is again emphasized that this is but a preliminary report. Detailed analysis of the results will be presented in due course, and compared against those for fascial repairs, Bassini, and simple herniotomies, as performed in Woodend and Oldmill hospitals.

SUMMARY

1. The place of fascia in the repair of hernias is considered, and its relative advantages and disadvantages assessed.

2. It is concluded that there is room for further improvement in hernial repair, and that it may be possible to evolve a more effective repair than that given by fascia.

3. The history and use of the "cutis" type of graft is described, and the essentials of the histology of these grafts indicated both for animals and for the human subject. On the basis of these findings it is suggested that there is no risk of later epidermoid or other cyst formation as a result of their use in hernial repair, and it is shown that in the cutis graft the epidermis is not completely removed.

4. An investigation into the use of whole skin grafts in preference to cutis grafts is described and the position to date given. The findings in both animals and in man in whom these grafts have been used to repair tissue defects are presented, and it is considered that the method is safe and promising of good results.

5. The technic of the operation in the case of indirect inguinal hernia is submitted and commented upon. The results in 137 cases of hernia repair, including several varieties, are presented.

6. Photographs are used to illustrate essential points in technic.

7. It is emphasized that this is a very preliminary report, and that later results will be published in the future.

Finally, I wish to express my thanks to Dr. Rae, D.P.H., Medical officer of Health for Aberdeen and Superintendent of these hospitals, for permission to perform and publish this work, to Dr. John Smith, D.Sc., F.R.C.P., Director of Aberdeen City Hospital, for facilities in his laboratory, and to Surgeon Lieutenant Anthony Smith, R.N.V.R. who took the photographs.

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OPERATIVE CURE OF INGUINAL HERNIA IN INFANCY AND CHILDHOOD*

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IN the young, the subject of inguinal hernia is predominantly concerned with the indirect type. Direct hernia is unusual in children, constituting definitely less than 1 per cent of all the inguinal hernias. To approach the problem of adequate surgical treatment of the common type, one must review the embryological development of a preformed indirect sac and the mechanical and anatomical peculiaritites of the inguinal region in its relationship to such a preformed or congenitally indirect sac.

During the third month of fetal life, an evagination of peritoneum, the processus vaginalis, appears at the site of the future internal ring and emerges through the anterior abdominal wall. It enlarges slowly from the fourth to the seventh month while the testis lies stationary in the iliac fossa close to the pelvic brim in the vicinity of the anterior abdominal wall. Descent of the testis through the inguinal canal into the scrotum occurs behind the advancing processus during the seventh, eighth and ninth months. Entering the scrotum, the testis and cord become enfolded by the processus which forms an incomplete investment. At no point are the testis and cord completely surrounded by the processus. At this stage, therefore, the tunica vaginalis, or that portion of the processus which lies in contact with the testis, has a cavity which is directly continuous with the cavity of the processus lying in the inguinal canal, which in turn is directly continuous with the general peritoneal cavity. This preformed sac remains patent at birth or soon after in 30 to 50 per cent of infants, according to estimates set forth by some writers.[3,4,6]

Normally obliteration of the processus vaginalis occurs from the internal ring to a short distance above the testis. Obliteration is apparently aided by the pressure of the muscular abdominal wall associated with both a loss of mesothelium and solidification, forming the funicular ligament. If the obliteration is not complete at birth, there are several possibilities: (1) If the entire processus, including the tunica, remains open, abdominal contents may enter it and form a hernia down to the lower pole of the testis, the so-called "congenital" hernia. (2) If the processus closes from a point just above the testis to a short distance below the internal ring, abdominal contents may enter it and form a hernia, the so-called "acquired" hernia. (3) If the processus narrows but does not obliterate at one or more points from just above the testis to a short distance below the internal ring, a hydrocele of the tunica vaginalis or of the cord, with or without an apparent hernia, the so-called "congenital" hydrocele, may develop.

Of course, in any of these three common types of inguinal hernia in children, should no abdominal contents enter the open processus and nothing occur to keep it open, the processus will be gradually obliterated in many cases.

Basically the inguinal canal is not weak. It is so powerfully constructed that if there is no patent processus vaginalis awaiting occupancy by an intra-abdominal tenant, it is impossible to produce an indirect inguinal hernia no matter how much force the child may exert in crying, straining or any other form of violent effort. During infancy, the internal ring is posterior to the external ring. The length of the inguinal

* From the Children's Surgical Service of Bellevue Hospital, New York.

canal is therefore represented by the thickness of the abdominal wall. As the child grows, the internal ring is carried upward and outward, rendering the canal longer and more oblique. Then, however, during increased intra-abdominal pressure, the semi-sphincteric fibers of the internal oblique, which exert a lifting power, are called into play. This brings into action a corresponding amount of resistance over the inguinal canal.

Two anatomical conditions emphasize the congenital origin of the indirect inguinal hernia: (1) The vas deferens and blood vessels of the cord have a uniform relationship to the hernial sac. (2) An indirect inguinal hernia is more frequent on the right side. This is apparently related to the later descent of the right testis as compared to the left testis. The difference in time of descent is naturally compensated for by the usual final higher position of the right testis in the scrotum, thereby equalizing the time of obliteration of the right and the left processus vaginalis. However, if the difference in the process on both sides be enhanced, it would account for the greater frequency of indirect inguinal hernia on the right side.

In 1938, since it was clear to us that an inguinal hernia in a child is not due to any weakness or abnormality of the abdominal muscles or aponeuroses but is solely due to the presence of a preformed sac, we relinquished the common types of hernia repair and began to utilize an operative procedure which only isolates and ligatures the neck of the sac. In that manner we obviated the possible danger of testicular atrophy by: (1) not transplanting the cord with resulting compression of the delicate vessels of the cord, (2) not dislocating the testis from its natural bed, which practically always causes postoperative reactive swelling of the testis, and (3) not performing extensive dissection of the sac from the cord structures with resulting injury of the vessels of the cord. Furthermore, by eliminating an extensive dissection of the sac with plastic repair of the inguinal canal, we did not disturb the anatomical relationships of normal muscular and aponeurotic structures so that attentuation of these structures with new weaknesses would result.

In attempting to imitate the natural process without disturbing the anatomical relationships of the inguinal structures, we do not believe that pulling the neck of the sac down through the external ring without opening the inguinal canal is a safe procedure. This type of operation has been done by many European surgeons, e.g., Kocher, Stiles and numerous contemporaries. We prefer to use an operation which is quite similar to that done by Philip Turner, Surgeon to Guys Hospital, 1920–1925. Reports of the results of two American surgeons[1,2] who used a similar operation have been incomplete.

The following is a description of our operation of choice: (1) An incision 1½ inches in length is made over the middle third of the line between the anterior superior iliac spine and the pubic tubercle. (2) The external oblique aponeurosis is incised in the direction of its fibers, but the external ring is left intact. (3) After Poupart's ligament is visualized, the fibers of the cremaster are separated, exposing the cord. (4) The sac and cord structures are picked up with a forceps in the lower angle of the wound. (5) The sac is dissected free of the cord structures at one level and transected. (6) The sac is then completely cleared proximally to its neck. (7) The neck of the sac is doubly transfixed and ligated, and the redundant sac between the level of transection and the ligature is excised. (8) The distal sac is permitted to drop back into the wound without further treatment. (9) The external oblique aponeurosis, Scarpa's fascia and skin are closed in layers.

RESULTS

The operation described, was performed upon 186 patients by all members of the attending and resident staff during the period from January, 1938, until May,

1944, inclusive. Of these patients, eighty-four had given incorrect addresses or had moved, and could not be contacted for follow-up observation. Among the remaining 102 patients, seventy-eight appeared for follow-up examination.

In the group of seventy-eight patients followed, eighty-eight operations for inguinal hernia were performed since ten were bilateral. The distribution of operations according to the age of the patient was as follows: (Table I):

TABLE I

Age of patient	2 mo.	3 mo.	6 mo.	8 mo.	1 yr.	2 yr.	3 yr.	4 yr.	5 yr.	6 yr.	7 yr.	8 yr.	9 yr.	10 yr.	11 yr.	12 yr.	13 yr.
No. of operations performed	2	2	1	1	3	6	4	7	8	7	11	10	8	6	3	8	1

In seventy-nine operations, silk was used and in nine catgut was used. Seven of the patients were females; all had unilateral hernias.

The following table (Table II) presents the relationship of the period of follow-up to the number of cases examined:

TABLE II

Period of follow-up	6 mo.	1 yr.	2 yr.	3 yr.	4 yr.	5 yr.	6 yr.
No. of cases	5	14	22	10	12	17	8

There was one recurrence noted in the group. It occurred on one side of a bilateral hernia operation performed on a three months' old infant. The recurrence was found during the first six months following operation.

No case of testicular atrophy was noted in the series. In two cases, however, the testis on the side of the previous hernia was smaller than the other testis.

COMMENT

It is our belief that the one case of recurrence was not related to the type of operation used, but rather to its faulty technical execution. The sac was very thin, large, and in its scrotal portion, filled with bowel. During the operation, the sac was torn posteriorly proximal to its neck. The operator, at the time, thought that ligation of the sac might have been insecure. At the subsequent operation for recurrence, the sac was noted to contain a loop of bowel attached to the posterior wall as in a "sliding" type of hernia.

In the two cases in which the testis was smaller on the side of the hernia following repair of the latter, the preoperative note in the hospital charts did not indicate the size of the testes. However, in the group, three other cases were noted in which the testis on the side opposite to the hernia was subsequently found to be smaller than the other testis. Since no case of atrophy of the testis was noted on the homolateral side, these cases of inequality of the testes are of no significance.

Included in this series are several cases of hydrocele of the cord or of hydrocele of the tunica vaginalis, associated with or without a hernia upon clinical examination. (Figs. 1 to 6.)

When these patients remained in bed for several days or longer before operation, we observed that the hydrocele diminished in size or disappeared entirely. It is evident, therefore, that the hydrocele is produced only by the passage of fluid from the peritoneal cavity through a stenosed portion of the processus vaginalis into a wide patent portion or into the wide patent tunica vaginalis. Because of the stenosis, the fluid tends to remain in the wide portion as long as the patient assumes the erect position permitting the force of gravity to act. The accumulation of the fluid is further enhanced by the presence of a hernia proximal to the narrowed portion of the processus.

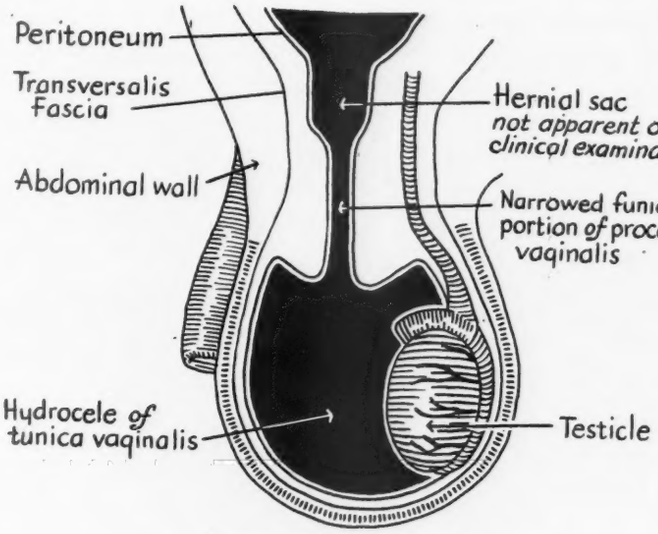

Fig. 1.

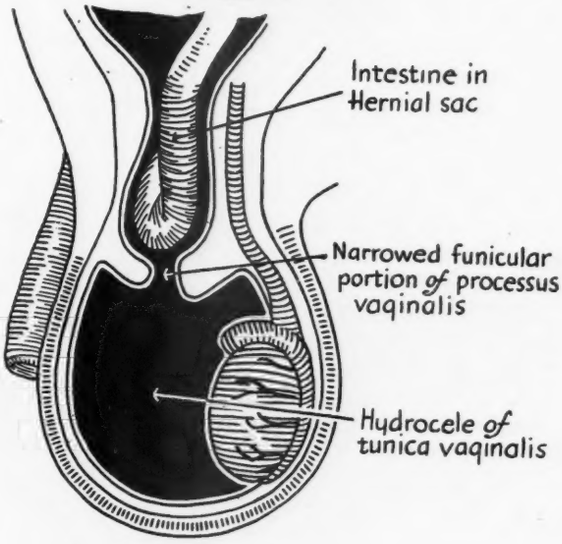

Fig. 2.

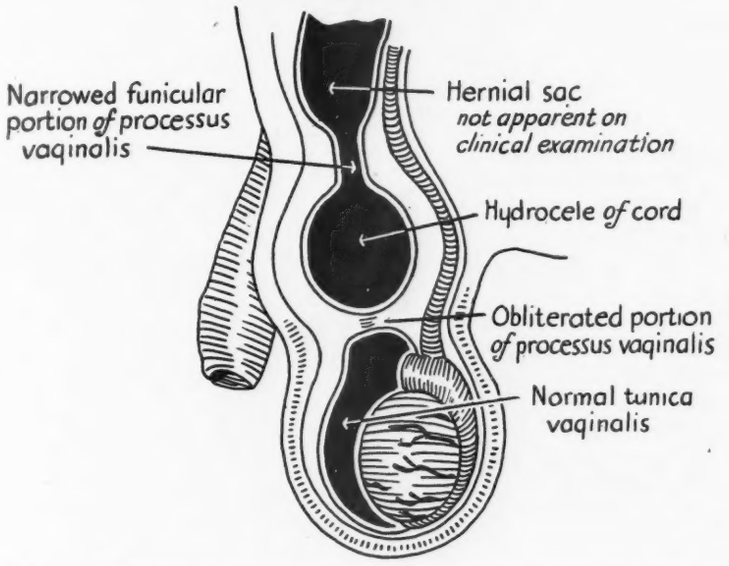
Narrowed funicular portion of processus vaginalis
Hernial sac not apparent on clinical examination
Hydrocele of cord
Obliterated portion of processus vaginalis
Normal tunica vaginalis

Fig. 3.

Fig. 1. Hydrocele of tunica vaginalis without an apparent hernia.
Fig. 2. Hydrocele of tunica vaginalis with an apparent hernia.
Fig. 3. Hydrocele of cord without an apparent hernia.

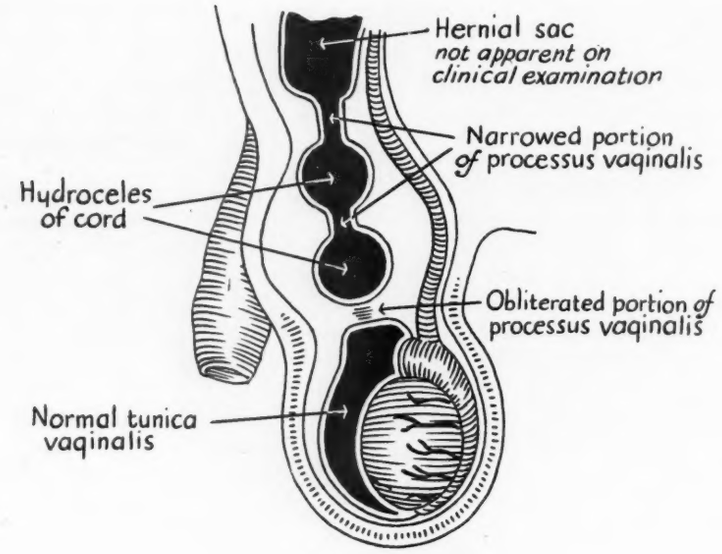

FIG. 4.

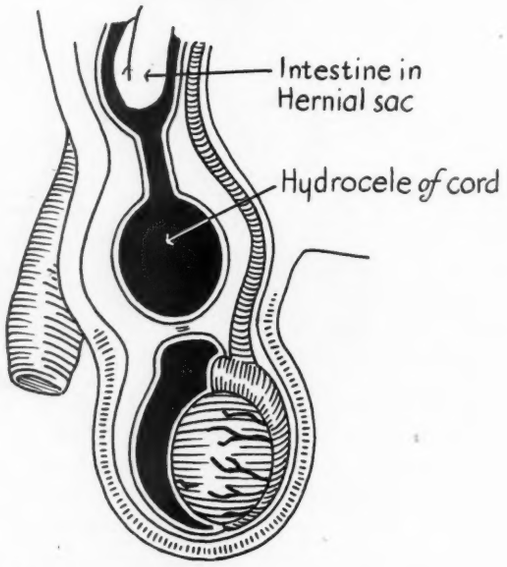

FIG. 5.

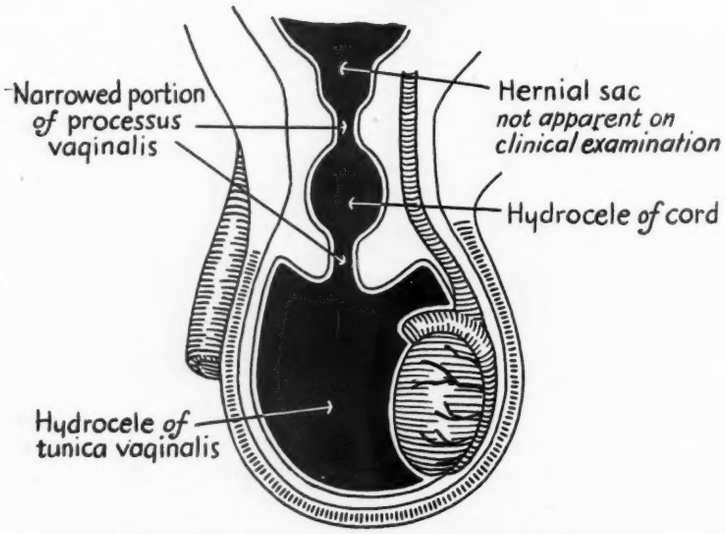

FIG. 6.

FIG. 4. Bilocular hydrocele of cord without an apparent hernia.
FIG. 5. Hydrocele of cord with an apparent hernia.
FIG. 6. Combination hydrocele of cord and tunica vaginalis without an apparent hernia.

It is possible, therefore, that in a child, there is no such thing as a pure hydrocele in which there is actual secretion of fluid by the lining cells of the processus vaginalis or tunica vaginalis. If this is true, a simple ligation of the hernial sac at its neck is enough to cure all hydroceles in children. In all those cases, in which this was done, the hydrocele disappeared. Sometimes it took several weeks or longer postoperatively for the fluid to be entirely absorbed.

We also noted, in dealing with these cases, that the largest hydrocele which appeared clinically as a typical hydrocele of the tunica vaginalis, at operation was usually found to be associated with a small hernial sac just beginning to appear at the internal ring. Furthermore, at operation, in some cases the stenosed portion of the processus could be demonstrated by passing a probe through it while in others it could not, appearing completely occluded. Yet, since simple ligation of the sac at the internal ring cured all these patients, the processus must have been patent but narrowed so much that it would not admit the passage of a probe.

Although we are convinced that ligation of the hernial sac cures all hydroceles in children, practically speaking, since some of these patients take some time postoperatively to absorb the fluid completely, it might be advisable to empty the hydrocele also at the time of operation. This can be done in either of two ways. If the hydrocele lies within the incision, it can be emptied by puncturing it with the scalpel. This situation will be found with a hydrocele of the cord. If the hydrocele lies below the incision, it can be emptied by needle aspiration through the scrotum immediately after the operation is completed. This situation will be found with a hydrocele of the tunica vaginalis.

SUMMARY

1. A follow-up study of eighty-eight cases of indirect inguinal hernia, in which seventy-eight patients were treated on the Children's Surgical Service of Bellevue Hospital by simple isolation and ligation of the neck of the sac, is presented.

2. The follow-up comprises a period from six months to six years.

3. One recurrence is noted within six months after operation, and is apparently not related to the type of operation performed.

4. No case of testicular atrophy is demonstrated.

5. A new method for the surgical treatment of hydrocele in the young is described.

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PRIMARY MALIGNANT DISEASE OF THE SMALL INTESTINE*

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PRIMARY malignancy of the small intestine is a challenge to modern surgery because of its rarity, difficulty of early diagnosis, extensive technic required, high operative mortality and grave prognosis. For this reason a study was made of thirty-eight consecutive cases of histologically proven primary malignancy of the small bowel encountered in the Jefferson Medical College Hospital. One unusual case is described in detail:

A B

FIG. 1. A, roentgenogram of small intestine following barium meal; showing fistula between mid-jejunum and terminal ileum. B, roentgenogram following barium enema showing the opaque material ascending from the terminal ileum through the fistula to the jejunum.

CASE REPORT

This case is that of a primary adenocarcinoma of the mid-jejunum producing a contact, fistulous communication with the terminal ileum, requiring extensive surgery which was successfully performed.

A sixty-nine year old white female was admitted to the Jefferson Medical College Hospital on May 29, 1940, complaining of recurrent attacks of epigastric pain, vomiting and diarrhea during the past two years, accompanied by a gradual loss of thirty pounds

* From the Samuel D. Gross Surgical Division of the Jefferson Medical College Hospital. Presented before the Philadelphia Academy of Surgery, November, 1942.

in weight. Increasing in frequency, these attacks finally occurred once or twice a week and lasted about two hours. The stools had been a putty color but never contained gross blood or mucous. A gastrointestinal *x*-ray study, February, 1938, showed only hypermotility of the small intestine. Past history and family history were negative for malignancy.

Positive findings were limited to the abdomen where there was a hard, moveable, orange-sized mass to the right of the umbilicus. There was no tenderness, distention or ascites.

The blood count showed hemoglobin 48 per cent, red cells 2,500,000, color index .98 and white cells 5,600. Repeated urine examinations were normal. The non-protein nitrogen of the blood was 23 mg. The bromsulfalein test revealed all dye removed from the blood serum in thirty minutes. The Van den Bergh reaction was negative direct. A quantitative Van den Bergh and icteris index were 0.6 mg. and 9 units, respectively. Plasma prothrombin time was 50 per cent of average normal. Stool examination was negative for gross and occult blood. Electrocardiographic study was normal.

Roentgenographic examination following a barium meal revealed a fistulous communication between the mid-jejunum and the terminal ileum. (Fig. 1A.) A barium enema revealed no abnormality in the large bowel but showed a considerable amount of opaque material entering the small intestine, passing from the terminal ileum through a fistula into the jejunum. (Fig. 1B.)

Preoperative treatment extended over a seven-day period and consisted of a high vitamin, high caloric, low residue diet, whole blood transfusions, vitamin K, bile salts and intravenous glucose in saline solution.

On May 31, 1940, under spinal anesthesia, the abdomen was opened through a mid-right rectus incision. A tumor was found involving the mid-jejunum and terminal ileum about 15 cm. from the ileocecal valve with the area of contact about 4 cm. in length in a side-to-side manner. (Fig. 2A.) This mass with involved bowel and regional mesentery was resected (Fig. 2B) followed by an end-to-end jejunojejunostomy, end-to-side ileo-ascending colostomy and inversion of the stump of the terminal ileum into the cecum. (Fig. 2C.) A temporary ileostomy was made using a soft rubber catheter. The abdomen was closed without drainage. The total operating time was two hours and fifteen minutes.

Pathologically the specimen consisted of two pieces of small intestine, jejunum and ileum, joined together in a side-to-side manner with

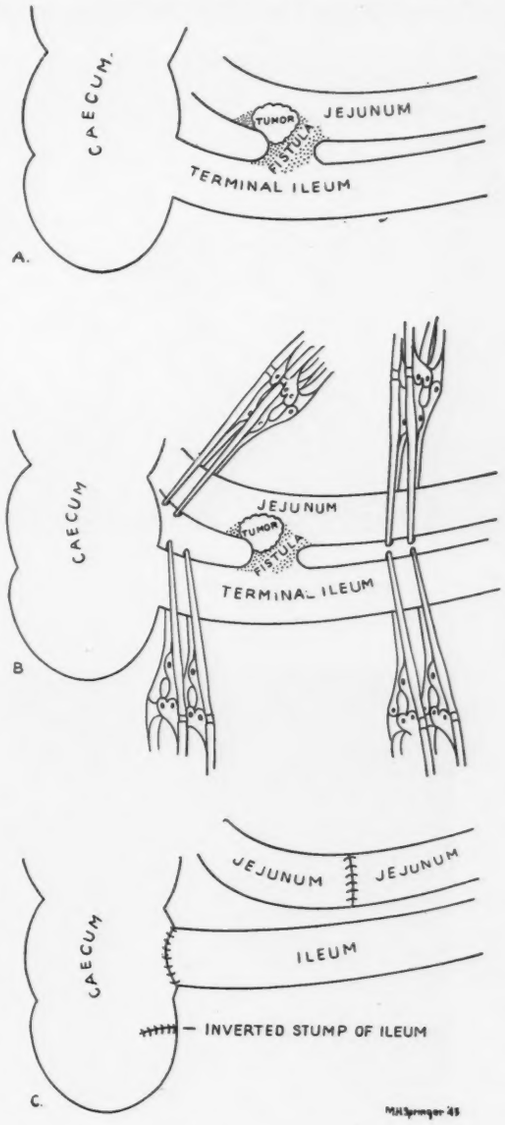
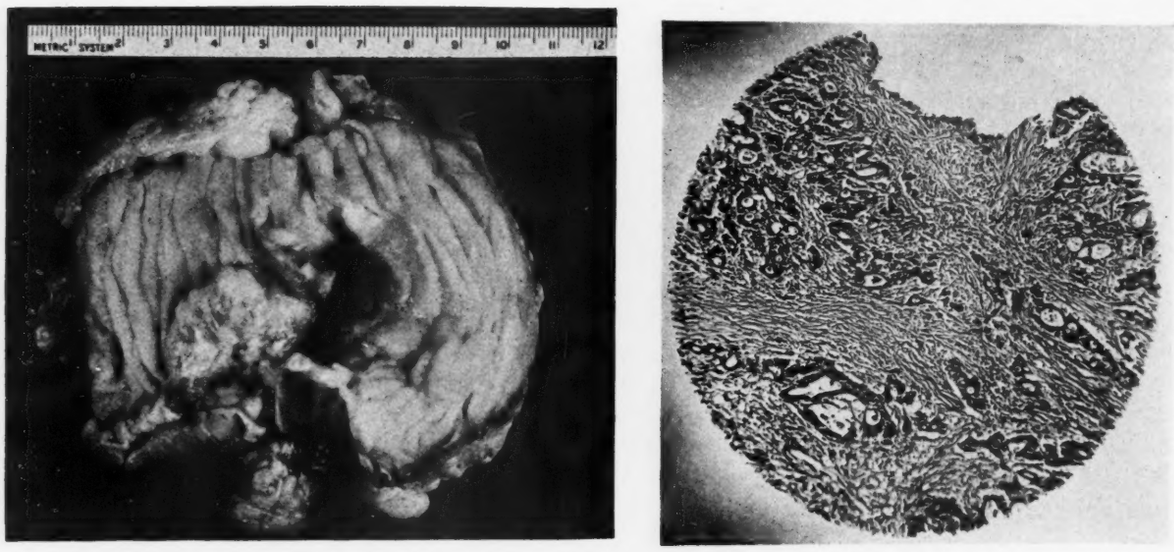


FIG. 2. A, diagram showing tumor of mid-jejunum with contact carcinoma and fistula to terminal ileum. B, diagram showing clamps in place prior to bowel resection. C, diagram showing intestinal anastomoses as well as inversion of terminal ileal stump completed.

an ostium 2 cm. in diameter connecting them. Both segments were 10 cm. in length. On the jejunal side of the ostium, extending along the mucosa, was a large cauliflower mass 3 cm. in diameter. (Fig. 3A.) In histological section (Fig. 3B) the normal mucosa was suddenly interrupted by a change in character of both the glands and the cells composing them. The glands were more numerous, arranged in disorderly fashion and infiltrated the sub-

mucous tissue. The cells had lost their secretory power and contained hyperchromatic nuclei and many mitoses.

250 cc. of citrated blood, intravenous fluids were continued for thirteen days maintaining a daily urine output of 1,500 cc. The ileostomy



A B

FIG. 3. A, opened specimen showing tumor of jejunum arising from margin of ostium. B, microphotograph of tumor shown in Figure 3A; 100 X.

A B

FIG. 4. A, postoperative roentgenogram one and one-half hours after barium meal. The outline of the intestine shows no distention and a normal functioning jejunojejunostomy. B, postoperative roentgenogram four and one-half hours after barium meal. The outline of the terminal ileum and colon shows that the ileo-ascending colostomy is functioning.

The diagnosis was primary adenocarcinoma of the jejunum.

Postoperatively in addition to 500 cc. of .8 per cent sulfanilamide solution parenterally daily for five days and two transfusions of tube was withdrawn on the eighth day. Following a satisfactory convalescence, the patient was discharged from the hospital on the thirty-third postoperative day, in excellent condition.

TABLE I

FREQUENCY OF INTESTINAL MALIGNANCY AMONG GENERAL AUTOPSIES COLLECTED FROM LITERATURE

Author	Source	Year	No. of Autopsies	Large Intestines		Small Intestines	
				No.	Per Cent	No.	Per Cent
Leichtenstern[14]	Vienna Gen. Hospital	1858 1870	34,523	770	2.23	33	.095
Maydi[17]	Vienna Gen. Hospital	1870 1881	20,480	100	.488	6	.029
Nothnagel[22]	Vienna Gen. Hospital	1881 1893	21,358	243	1.13	11	.051
Muller[20]	Path. Inst. of Berne	1886 1891	5,621	41	.729	9	.160
Heiman[10]	Hospitals of Prussia	1895 1896	20,054	1,708	8.50	20	.099
Meyer and Rosenberg[19]	Cook Co. Hosp. Mich'l. Reese Hospital	1931	10,876	569	5.23	10	.091
Nickerson and Williams[21]	Boston City Hospital	1937	11,206	343	3.05	10	.089
Christofferson and Jacobs[4]	Cook Co. Hospital	1929 1933	10,309	163	1.50	5	.048
Bowe and Neely[26]	Bryan Mem. Lincoln Gen.	1928 1937	1,191	181	15.1	8	.671
Medinger[18]	New Eng. Deac. Palmer Mem.	1927 1939	1,456	918	63.04	22	1.51
Total			137,174	5,034	3.66	134	.098

A roentgenographic study of the small intestine and colon, three and one-half months after operation, revealed no abnormality. (Figs. 4A and B.) At the present time, four years after operation, the patient is entirely symptom free.

TABLE II

FREQUENCY OF SMALL INTESTINAL MALIGNANCY AMONG GENERAL INTESTINAL MALIGNANCY—UPPER TABLE CARCINOMA, LOWER TABLE SARCOMA

Author	Intestinal Carcinoma	Small Intestinal Carcinoma	
		No.	Per Cent
Jefferson[12]	4,177	130	3.1
Meyer and Rosenberg[19]	569	10	1.7
Aaron[1]	343	17	4.9
Ackman[2]	600	7	1.0
Hinz[11]	584	18	3.08
Total	6,273	182	2.9

Author	Intestinal Sarcoma	Small Intestinal Sarcoma	
		No.	Per Cent
Crowther[5]	191	117	61.2
Ullman and Abeshouse[31]	126	78	61.9
Staemmler[28]	394	218	55.3
Liu[16]	12	9	75.0
Weeden[33]	12	10	83.3
Graves[9]	249	166	67.3
Total	984	598	60.7

INCIDENCE

Primary small intestinal malignancy occurs in 0.1 per cent of all general autopsies while that of the large is found in 3.6 per cent, or thirty-six times as frequent. (Table I.) Among general intestinal carcinoma and sarcoma, the small bowel is involved in 3 and 60 per cent, respectively. (Table II.) Table III shows that malignancy in general occurs with about equal frequency in each of the three divisions of the small intestine, that carcinoma is found twice as often as sarcoma and that the ileum ranks lowest for carcinoma but highest for sarcoma. Of 305 collected primary duodenal carcinomas, Eger[7] found 62 per cent in the second portion, 24 per cent in the first, 12 per cent in the third portion and 2 per cent involved the entire duodenum. Small intestinal carcinoids comprise 0.02 per cent of autopsy and surgical

specimens, 8.3 per cent of all small intestinal neoplasms and occur chiefly in the ileum but occasionally in the jejunum and duodenum (Ariel[3]).

contradistinction to carcinoma. Carcinoids are usually small, firm, submucosal yellow nodules which rarely produce obstruction, grow slowly and metastasize in 25 per

TABLE III

INCIDENCE AND DISTRIBUTION OF CARCINOMA AND SARCOMA AMONG PRIMARY SMALL INTESTINAL MALIGNANCIES

Author	Source	Years	No. of Cases	Duodenum				Jejunum				Ileum			
				Carcinoma		Sarcoma		Carcinoma		Sarcoma		Carcinoma		Sarcoma	
				No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Raiford[25]	Johns Hopkins Hosp.	Up to 1931	35	7	20.0	1	2.9	4	11.4	1	2.9	3	8.5	19	54.3
Stein[29]	Edward Hines Jr. Hospital	1931 1936	7	2	28.5	0	....	2	28.5	1	14.5	2	28.5	0	
Doub and Jones.[6]	Henry Ford Hospital	Up to 1936	13	9	69.3	1	7.7	3	23.0	0	....	0	....	0	
Rowe and Neely.[26]	Lancaster Co. Lab. Bryan Memorial Hosp. Lincoln Gen. Hosp. Lincoln Clinic	1928 1937	8	1	12.5	0	....	5	62.5	0	....	0	....	2	25.0
Ragins and Shively.[24]	Cook Count Hospital	1929 1938	14	3	21.5	1	7.1	7	50.0	0	....	1	7.1	2	14.3
Goldberg[8]	Presbyterian Hosp., Newark, N.J.	1930 1938	7	3	42.8	0	....	1	14.4	3	42.8	0	....	0	
Medinger.[18]	Path. Lab. of New England Deaconess Hosp. Palmer Memorial Hosp.	Up to 1939	18	3	27.8	0	....	8	44.4	0	....	2	11.1	5	16.7
Weber and Kirkland[32]	Mayo Clinic	Up to 1942	84	23	27.4	2	2.4	31	36.9	2	2.4	21	25.0	5	5.9
Swenson[30]	Presbyterian Hosp. New York, N.Y.	Up to 1943	45	8	17.8	7	15.5	9	20.0	8	17.8	5	11.1	8	17.8
Authors' series.	Jefferson Hospital	Up to 1943	38*	14	37.8	0	....	5	13.5	6	13.5	4	10.8	9	24.4
Total			269	73	27.2	12	4.5	75	27.8	21	7.8	38	14.1	50	18.6

* Two cases of malignant leiomyoma of the jejunum previously reported by Klopp and Crawford,[13] and 1 duodenal carcinoma previously reported by Lieber, Stewart and Morgan.[15]

PATHOLOGY

Primary carcinomas of the small intestine are divided by their gross morphology into three types which in order of frequency are the stenosing (Figs. 5A and B), the infiltrating or ulcerative and the polypoid. (Fig. 6.) Primary sarcoma usually extends toward the mesentery without producing obstruction (exception observed in Figs. 7A and B) or hemorrhage, in cent chiefly to the regional nodes and only occasionally to the liver (Ariel[3]).

Thirty-one of the thirty-eight cases of primary small intestinal malignancy in this series had evidence of extension or metastasis most frequently to the regional nodes and liver. (Table IV.) Of the seven duodenal carcinomas, there was no metastasis in one, regional node involvement in one and widespread metastasis in five. Parsons and Mullins[23] believe that am-

pullary malignancies first extend along the common duct and into the pancreas. In our group of seven ampullary lesions, all of the onset of symptoms was usually insidious, although occasionally it was sudden with a perforation, a severe hemorrhage

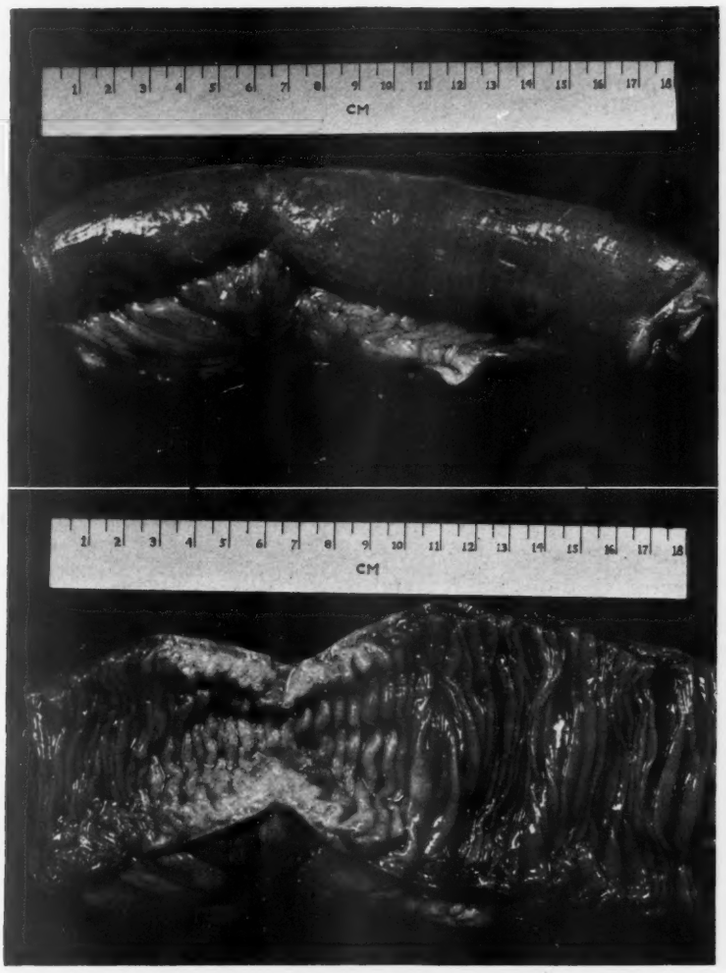


Fig. 5. A, stenosing adenocarcinoma of the jejunum. B, opened specimen of stenosing adenocarcinoma of the jejunum.

which were carcinoma, five showed metastasis, but the pancreas was only involved in one. Of the twenty-four jejunal and ileal malignancies, four were without evidence of extension or metastasis, nine involved only the regional modes and eleven had widespread metastasis. There were no malignant carcinoids.

DIAGNOSIS

The early diagnosis of primary malignancy of the small intestine is dependent upon careful evaluation of the history, physical, laboratory, and roentgen ray findings. Among these thirty-eight cases or an acute intestinal obstruction (Figs. 7A and 7B); the duration of symptoms varied from five days to three years, with an average of seven months. Lesions of the ampullary portion produced biliary obstruction before intestinal obstruction in all cases; occasional intermittency and variation in intensity of the jaundice may result from sloughing of the tumor, increased intrabiliary tension forcing bile through the point of constriction and the subsidence of papillary edema. Over 75 per cent of the small intestinal neoplasms in this series were palpable, usually fixed in the duodenum and mobile in the

jejunum and ileum. Laboratory studies not only aided in the diagnosis, but also in determining the severity of the disease and served as a guide in the pre- and postoperative management. Of the twenty-nine cases with roentgenographic gastrointestinal studies, the lesion was demonstrated in seventeen and suggested in another; the examination was unsatisfactory in two duodenal carcinomas and one extensive sarcoma of the ileum because of vomiting. Eight neoplasms not demonstrated following a complete gastrointestinal examination were one carcinoma of the ampulla of Vater, two carcinomas and one sarcoma of the jejunum and two carcinomas and two sarcomas of the ileum, even though the duration of symptoms for this group averaged fourteen months.

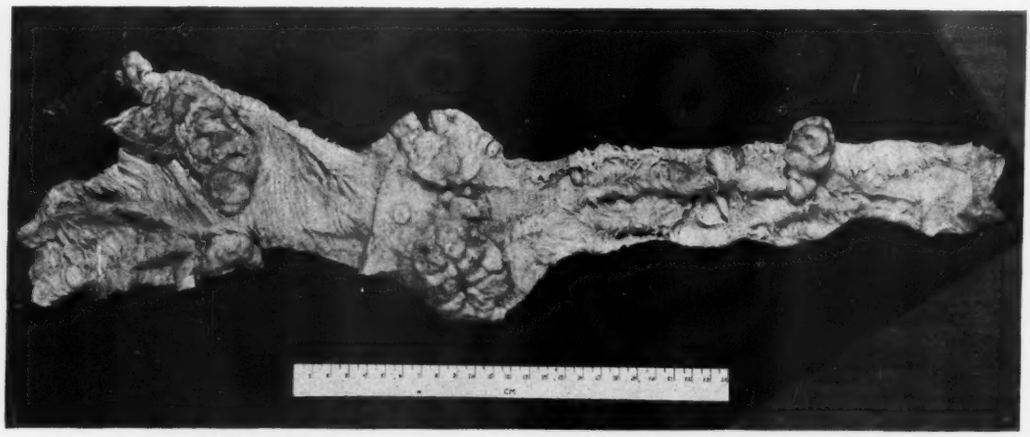


FIG. 6. Multiple polypi of ileum having undergone malignant change.

TREATMENT AND RESULTS

In addition to decompression of the gastrointestinal tract, it is essential that these patients be improved medically to a maximum degree before operation and supported after operation by correcting any fluid and electrolyte imbalance,

TABLE IV

INCIDENCE AND SITE OF METASTASES

	No. of Cases	Without Metastases	Regional Nodes	Liver	Pancreas	Retroperitoneal Nodes	Peritoneum	Lung	Adrenals	Kidney	Cecum	Transverse Colon and Mesocolon	Gallbladder	Ovary	Brain	Lumbar Vertebra	Spleen	Ribs
Duodenum—Carcinoma	7	1	6	5	3	..	2	1	..	..	..	..	1					
Ampulla of Vater—Carcinoma	7	2	3	4	1													
Jejunum—Carcinoma	5	3	2	1	..	..	..	..	..	..	..	1						
Jejunum—Sarcoma	6	..	6	1	..	..	..	..	..	1	..	1	..	1				
Ileum—Carcinoma	5	..	5	1	..	2	1	1	1	1	1	..	..	..	1	1	..	1
Ileum—Sarcoma	8	1	7	..	..	1	..	..	1	..	1	..	..	..	..	..	1	
Total	38	7	29	12	4	3	3	2	2	2	2	2	1	1	1	1	1	1

anemia, vitamin and plasma protein deficiency and impaired function of the heart, liver and kidneys.

Fig. 7. A, specimen of lymphosarcoma of the jejunum with intussusception producing obstruction. B, opening specimen of lymphosarcoma of the jejunum with intussusception.

The type of operative procedure depends upon the condition of the patient, the location and extent of the growth and the presence or absence of complications as jaundice or metastasis. Early and adequate resection of the growth and regional mesentery with re-establishment of the continuity of the bowel is the treatment of choice.

In this series a variety of surgical procedures was performed. (Table v.) The only duodenal malignancy resected was a carcinoma in the third portion. The third and fourth portions were resected followed by an antecolic side-to-side duodenojejunostomy anastomosing the second portion of the duodenum, just distal to the

ampulla of Vater, to the jejunum 10 inches from the ligament of Treitz. The patient was well ten months later (Shallow, Eger, Carty[27]).

in two, without metastasis, had they survived the first stage.

All the jejunal lesions found at operation were resected followed by primary anasto-

TABLE V

OPERATIVE PROCEDURES EMPLOYED IN AUTHORS' SERIES

	Duodenum Carcinoma	Ampulla of Vater Carcinoma	Jejunum		Ileum		Total
			Carcinoma	Sarcoma	Carcinoma	Sarcoma	
Resection; side-to-side duodenojejunostomy	1	..	..	..	..	..	1
T-tube drainage of common duct	1	..	..	..	..	..	1
Gastro-enterostomy	1	..	..	..	..	..	1
Cholecystogastrostomy	..	3	..	..	..	..	3
Gastro-enterostomy, cholecytojejunostomy	1	..	..	..	..	..	1
Chosecysto-enterostomy, Y-type; gastro-enterostomy	..	1	..	..	..	..	1
Cholecystogastrostomy, ligation of common bile duct, gastro-enterostomy, entero-enterostomy	..	1	..	..	..	..	1
Resection; end-to-end anastomosis	..	..	2	2	1	1	6
Resection; three separate end-to-end anastomoses	..	..	..	..	..	1	1
Resection; end-to-end anastomosis with proximal enterostomy	..	..	..	..	..	1	1
Resection; side-to-side anastomosis	..	..	2	..	..	..	2
Resection of jejunum and portion of transverse colon, end-to-end anastomoses of each	..	..	..	1	..	..	1
Resection of portion of jejunum followed by end-to-end anastomosis; resection of terminal ileum followed by end-to-side ileo-ascending colostomy	..	..	1	..	..	..	1
Resection; end-to-side anastomosis of ileum to splenic flexure of colon	..	..	..	..	1	..	1
Resection; ileotransverse colostomy, proximal ileostomy	..	..	..	..	..	1	1
Exteriorization of tumor	..	..	..	..	..	1	1
Exploratory laparotomy	..	..	..	..	1	2	3
Total No. of operations	4	5	5	3	3	7	27

In the ampullary group, the bile was redirected to the gastrointestinal tract in all cases, but resection was contemplated

moses. One, because of a contact carcinomatous fistula, also required a resection of the terminal ileum followed by an

end-to-side anastomosis of the ileum and ascending colon (see case report). Another produced contact sarcoma to the transverse colon which was also successfully resected and anastomosed primarily. The patient is well twelve years later. Another died of sarcomatous metastasis after fifteen years (Klopp and Crawford[13]).

TABLE VI
OPERATIVE MORTALITY AMONG TWENTY-SEVEN PRIMARY MALIGNANCIES OF THE SMALL INTESTINE

Location and Type of Neoplasm	No. of Operations	Post-operative Mortality	Percentage Mortality
Duodenum Carcinoma	4	2	50
Ampulla of Vater Carcinoma	5	3	60
Jejunum			
Carcinoma	5	1	20
Sarcoma	3	1	33
Ileum			
Carcinoma	3	1	33
Sarcoma	7	4	57
Total	27	12	44

In the ileum, six malignant tumors were resected and primary anastomoses were performed, another was merely exteriorized and three, not resectable, were administered roentgen therapy. Of the resected group, one lymphosarcoma is well seven years later, and the remaining two, which survived the operation, are lost to follow-up.

The results of surgery compare very unfavorably with those for malignancy of the large intestine. Since small intestinal malignancy metastasizes early and its diagnosis is difficult, it is usually beyond the point of curative resectability when operation is performed. The prognosis of sarcoma seems better than carcinoma. Primary malignancy is most favorable in the jejunum and least in the duodenum. Of these thirty-eight cases, twenty-seven were treated surgically with an operative mortality of 44 per cent. (Table VI.) Four are living and well twelve, seven, and four years, and ten months, respectively, after operation; four others lived fifteen, four, three and one year respectively; sixteen survived six months or less; three have been lost to follow up and eleven expired without surgery. (Table VII.) The most common causes of death were metastasis and circulatory failure. (Table VIII.)

SUMMARY AND CONCLUSIONS

Thirty-eight consecutive and verified cases of primary malignancy of the small intestine are reviewed and an unusual case of jejunal carcinoma, producing a contact

TABLE VII
END RESULTS OF THIRTY-EIGHT PRIMARY MALIGNANCIES OF THE SMALL INTESTINE

Location and Type of Neoplasm	No. of Cases	Expired without Operation	Duration of Life Following Operation									
			1 Week	1 Mo.	3 Mo.	6 Mo.	1 Yr.	3 Yr.	4 Yr.	15 Yr.	Living and Well	Lost to Follow-up
Duodenum Carcinoma												
Supra-amp	3	2	..	1								
Peri-amp	3	1	1	1								
Infra-amp	1	..	..	..	..	..	..	..	..	..	1 (10 mo.)	
Ampulla of Vater Carcinoma	7	2	3	..	..	..	1	..	..	..	.....	1
Jejunum Carcinoma	5	..	1	..	..	1	..	1	1	..	1 (4 yr.)	
Jejunum Sarcoma	6	3	1	..	..	..	..	..	..	1	1 (12 yr.)	
Ileum Carcinoma	5	2	..	1	..	..	..	..	..	..	.....	2
Ileum Sarcoma	8	1	3	1	1	1	..	..	..	..	1 (7 yr.)	
Total	38	11	9	4	1	2	1	1	1	1	4	3

TABLE VIII
CAUSES OF DEATH IN THIRTY-FOUR CASES

Causes of Death	With Operation	Without Operation
Metastasis	8	8
Circulatory failure	5	
Acute intestinal obstruction due to metastasis	2	
Pneumonia	2	
Peritonitis	2	
Hepatorenal insufficiency	1	
Gastrointestinal hemorrhage	..	1
Liver and pancreatic necrosis	..	1
Diabetic acidosis	..	1
Lost to follow-up	3	
Total	23	11

fistula to the terminal ileum, is described in detail.

The incidence of small intestinal malignancy among general autopsies is found to be .1 per cent or about 36 times less frequent than large intestinal malignancy. Three per cent of intestinal carcinomas and 60 per cent of intestinal sarcomas occur in the small intestine. Carcinoma is twice as common as sarcoma. Malignancy in general occurs with about equal frequency in all three divisions of the small intestine; however, the ileum ranks lowest for carcinoma but highest for sarcoma.

Careful roentgenographic study seems to be the best aid to diagnosis of these lesions at the present time.

Although the treatment of choice is early and adequate resection of the growth and regional mesentery with re-establishment of the continuity of the bowel, the type of operative procedure depends upon the condition of the patient, the location and extent of the growth and the presence or absence of complications as jaundice or metastasis.

The operative mortality, 44 per cent for the entire series, is highest in the duodenal group and lowest in the jejunal group.

The results of surgery in small intestinal malignancy compare unfavorably with those for malignancy of the large intestine.

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Chronic intestinal stasis with possible absorption of toxic matter may result from intestinal atony, the presence of prenatal or acquired peritoneal bands or sheets of membrane especially over the lower ileum and colon, as *Jackson's membrane* or veil, *Lane's kink* or *Price's elbow*. *Payr's disease* is due to a kink at the splenic flexure of the colon.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

Case Reports

SURGICAL MANAGEMENT OF LARGE TUMORS OF THE NECK

REPORT OF TWO UNUSUAL CASES

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THE modern surgeon seldom sees tumors of enormous size. A few decades ago such tumors were common. In recent years, however, owing to the availability of surgical consultation, improved methods and increased awareness of the patient and physician of the importance of early diagnosis and treatment, tumors are usually relatively small when diagnosed and treated. MacCarty has illustrated this trend statistically. Since 1907, he has measured and weighed all neoplastic lesions removed at the Mayo Clinic. He has found, for example, that uterine fibromyomas in 1912 had an average weight of 1,533 Gm.; in 1941, the average weight was 320 Gm. In 1912, the ovarian tumors averaged 4,410 Gm. in weight and in 1941 they averaged 550 Gm.

In recent months we have seen two unusual tumors of the neck. Both of these were outstanding because of their very large size. The surgical management of large cervical tumors presents some special problems which we wish to discuss.

CASE REPORTS

CASE 1. Large cervical and intrathoracic adenomatous goiter with hyperthyroidism; auricular fibrillation and congestive cardiac decompensation: subtotal thyroidectomy: The patient, a white woman, aged sixty-two years, entered the Mayo Clinic on September 15, 1944, complaining of dyspnea, palpitation, swelling of the ankles and a large tumor of the neck. She stated that forty-four years prior to admission, when she was eighteen years of age, she had first noted a small cervical mass in the region of the thyroid gland. The tumor had shown little tendency to enlarge except during pregnancy. With each of her six pregnancies the mass had grown rapidly in size. Postpartum the tumor always seemed to stop growing but it did not regress in size. Consequently, twenty years ago at the time her last child was born, the tumor was approximately the size of a small grapefruit. In the ensuing seventeen years little change was noted in the size of the mass and it did not cause symptoms except for the discomfort associated with its weight. In 1941, three years before admission, the tumor began to undergo progressive and rapid enlargement. In June, 1944, intermittent diarrhea and indigestion developed. The patient noticed that she was dyspneic on exertion, that she could not breathe well when lying flat in bed and that her heart beat was rapid and disturbing. Edema of the ankles became evident and she rapidly lost strength. All of these symptoms gradually became worse and finally forced her to seek medical aid.

Physical examination revealed a dyspneic, obviously ill white woman with a remarkably large tumor of the neck. The tumor was composed of a mass in the midline the size of an infant's head and two large lateral lobes of somewhat smaller dimensions. The heart was enlarged and in the state of auricular fibrillation. The apex pulse was 150, the radial pulse 130 beats per minute. There were many moist and crepitant râles throughout both pulmonary fields. The liver was enlarged and palpable 8 cm. below the right costal margin and there was moderate pitting edema of both ankles.

Roentgenographic examination of the neck revealed a very large superficial cervical mass, which extended substernally. There were marked compression of the trachea and deviation of it to the right. Roentgenograms of the thorax showed cardiac enlargement and bilateral pulmonary congestion. The electrocardiogram showed typical auricular fibrillation with a ventricular rate of 150 beats per minute. There was retention of dye, grade 3 (on the basis of 1 to 4, in which 1 designates the mildest and 4 the most severe condition), to the bromsulfalein liver function test. The basal metabolic rate was +49 per cent. The concentration of hemoglobin was 12.7 Gm. per 100 cc. of blood and leukocytes numbered 6,400 in each cubic millimeter of blood.

A diagnosis of adenomatous goiter with hyperthyroidism, auricular fibrillation and congestive cardiac decompensation was made.

The patient was hospitalized and treated medically for twenty-two days prior to surgical intervention. Rest in bed, compound solution of iodine (Lugol's solution), diuretics, sedatives and digitalization with lanatosid-C resulted in great improvement in her general condition. By the time of surgical intervention the peripheral edema and pulmonary congestion had entirely disappeared and the radical pulse was consistently less than 100 beats per minute. The patient was relieved of her dyspnea, palpitation and orthopnea. The basal metabolic rate was reduced to +18 per cent and repetition of the liver function test showed reduction in retention of dye to grade 2 (on the basis of 1 to 4).

Subtotal thyroidectomy was performed on October 7, 1944, with the patient under local (procaine hydrochloride 0.5 and 1 per cent), nitrous oxide and oxygen anesthesia. A large elliptic area of skin over the center of the mass was excised. The platysma muscle was divided and the ribbon muscles were separated and retracted. By careful dissection just above the suprasternal notch the trachea was located and its position marked by inserting a fine catgut suture, with ends left long, into the pretracheal fascia. The right superior thyroid vessels were isolated, doubly ligated and divided. The right inferior thyroid artery was ligated and then the substernal portion of the right lateral lobe was elevated. Similar procedures were carried out on the left side and the entire tumor mass was removed. At the conclusion of the operation all adenomatous tissue had been extirpated. Apparently normal thyroid tissue equal to one-half to three-fourths of a normal sized lobe was preserved on each side of the trachea. A small gauze wick was inserted as a drain and the skin was closed with metallic clips.

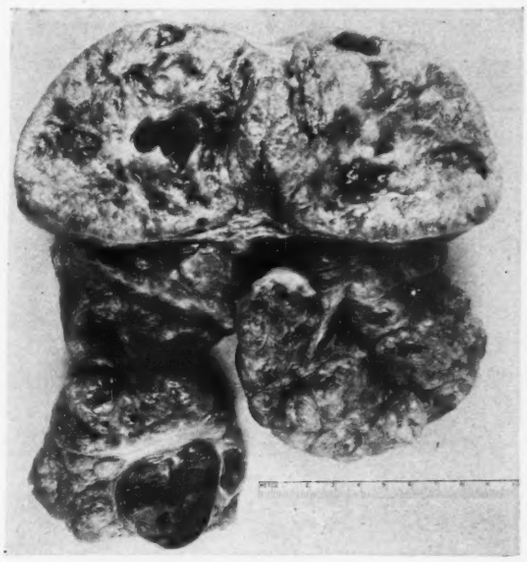

Fig. 1. Case 1. Adenomatous goiter with multiple degenerating and cystic colloid and fetal adenomas; weight 1,075 Gm.

Examination by the pathologist showed that the tumor weighed 1,075 Gm. The main mass of tissue removed measured 14 by 14 by 8 cm. (Fig. 1.) Grossly and histologically the tumor was composed of multiple fibrous, hyaline, granular, hemorrhagic and cystic degenerating colloid and fetal adenomas in a colloid thyroid.

Convalescence was essentially uneventful. The patient left the hospital on the eighth postoperative day and was dismissed from our care on October 31, 1944, twenty-four days after operation. At the time of dismissal she was feeling well, there had been no recurrence of her previous symptoms and, although auricular fibrillation persisted, the radial pulse was 70 to 80 beats per minute. Continued oral digitalis therapy was recommended.

Comment on Case 1. The redundant skin which will remain after removal of a very large cervical tumor should be excised at the beginning of the surgical procedure and the skin flaps fashioned so that they can be approximated without undue laxness. If there is doubt as to whether or not removal of the tumor can be

consummated, a straight line incision which can be hurriedly closed is best. This has the disadvantage, however, of making necessary a repetition of the time consuming procedure of securing hemostasis in the skin and subcutaneous tissues at the conclusion of the operation when the skin flaps are reconstructed.

Adequate exposure is a paramount necessity when one is operating on patients who have very large tumors of the neck. It is more important for the surgeon to be able to visualize easily the structures on which he is working than for the patient to have a small scar. To facilitate exposure the senior author routinely divides the deep cervical fascia transversely and ligates and sections the anterior jugular veins. These structures are then reflected along with the skin, subcutaneous tissues and platysma muscle. If the ribbon muscles cannot be easily retracted out of the operative field, they may be cut transversely and reunited at the conclusion of the operation. When the goiter is very large, however, these muscles are usually so thinned out and stretched that they are easily retracted.

After the skin, subcutaneous tissues, platysma muscle, deep cervical fascia and anterior jugular veins have been reflected and the ribbon muscles separated or divided, the trachea should be located. Large goiters not only cause deviation of the trachea but also frequently compress and soften it. There is considerable danger of tracheal collapse or further compression during manipulations incident to removal of the tumor. Immediate tracheotomy may be necessary and it is best to know the exact position of the trachea before the resection is begun. Blunt dissection immediately above the upper end of the sternum will usually locate it. A fine catgut suture with ends left long, placed in the pretracheal fascia, will serve as a guide during the operation. Furthermore, if it is brought out through the incision in the skin, it will guide the surgeon in case subsequent tracheotomy is necessary.

If a portion of the goiter is intrathoracic, the superior pole of the thyroid and the superior thyroid vessels should be isolated, doubly ligated and divided before one attempts to elevate the intrathoracic portion. This procedure facilitates mobilization of the lateral lobe and intrathoracic portion. If the inferior thyroid arteries are also ligated as an initial step, hemostasis will be facilitated.

The remainder of the procedure does not differ materially from the usual subtotal thyroidectomy.[2] It should be noted, however, that the fact that the original goiter was large does not justify a less thorough removal of the gland than if the goiter had been small. Regardless of whether the enlargement of the thyroid is great or small, the tissue remaining at the conclusion of the operation should not exceed the equivalent of one-half to one normal sized lobe. The only exception to this statement occurs in those cases in which in addition to a goiter there is severe nonspecific thyroiditis. In such cases, especially if the goiter is of the exophthalmic type, hypothyroidism or myxedema is prone to develop postoperatively.[8] In such cases it is permissible to leave a somewhat greater amount of thyroid tissue. We do not know of any direct evidence to prove that this practice will minimize the incidence of postoperative hypothyroidism, however. In either event all adenomatous tissue must be extirpated.

Whenever a large goiter is removed, the cavity occupied by the gland will persist in part as a dead space at the conclusion of the operation. Such potential spaces are most often encountered when a portion of the tumor is intrathoracic. Unless such cavities are drained, serum will accumulate and give rise to postoperative complications. The insertion of drains circumvents this possibility. For this purpose a strip of finely woven gauze seems preferable to the ordinary rubber drains, for in addition to allowing the escape of serum it may aid in hemostasis.

This patient also illustrates many points in the preoperative medical management of hyperthyroid patients suffering from decompensated cardiac disease. In the excellent publications of Haines, Pemberton and Miller and Davis and Howell this phase of the problem is fully discussed. We wish to state, however, in agreement with these authors, but contrary to the belief of some physicians, that the preoperative use of compound solution of iodine and preoperative digitalization in properly selected cases are of definite value for many persons suffering from adenomatous goiter and hyperthyroidism.

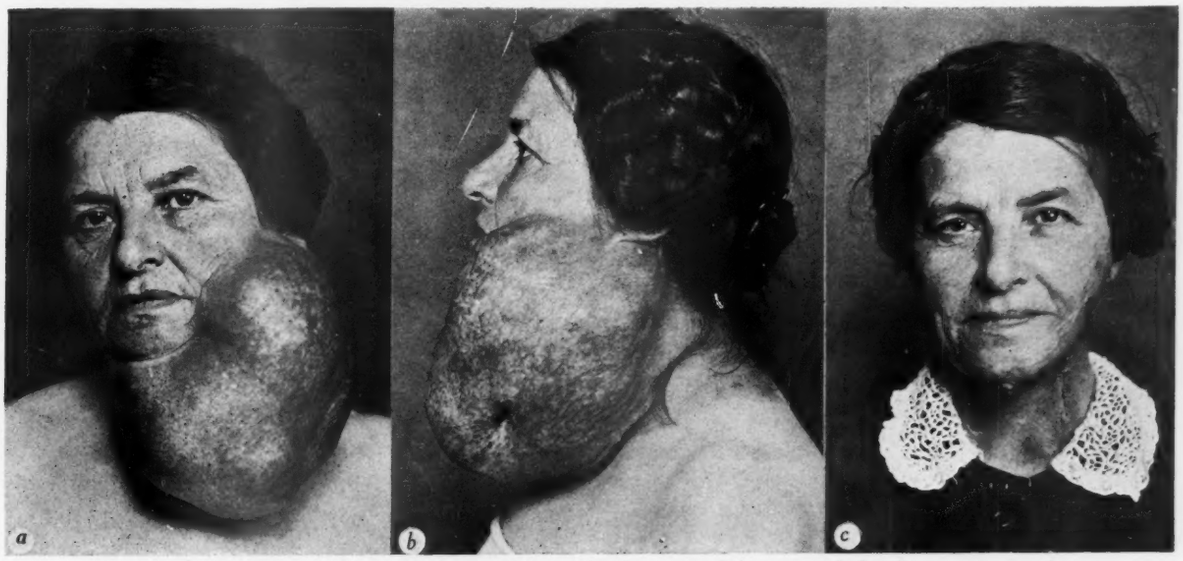

Fig. 2. Case 11. *a* and *b*, front and lateral views of large mixed tumor of the parotid gland; *c*, postoperative appearance of the patient.

Case 11. Huge mixed tumor of parotid gland; surgical excision. The patient, a white woman, aged sixty-one years, entered the Mayo Clinic on July 15, 1944, for treatment of a large tumor of the left side of the face and neck. She stated that forty-three years before, when she was eighteen years of age, she first noticed a small tumor about the size of a walnut in the left parotid region. Two years later it had grown appreciably and surgical excision had been performed. The patient did not know the pathologic type of the tumor removed at that time. Subsequently she was well and without evidence of recurrence for twenty-three years. Eighteen years prior to admission another small swelling in the left parotid region was noticed. In the intervening years it had grown gradually until it reached such tremendous proportions that the patient wearied of carrying the heavy weight of the tumor and sought medical advice. Aside from the discomfort of supporting the mass there had not been pain, dysphagia or other symptoms.

Physical examination revealed a well developed white woman. A tumor mass, which was almost as large as her head, protruded from the left side of the face and neck. (Fig. 2A and B.) The tumor was of firm, rubbery consistency and was distinctly nodular. It was relatively immobile and seemed fixed to the mandible and the deep structures of the neck. The overlying skin was atrophic and scarred and in some areas was adherent to the growth. There was no significant enlargement of the regional lymph nodes. The facial nerve was not affected. The remainder of the physical examination gave essentially negative results.

Roentgenograms of the tumor revealed regions of calcification. Roentgenograms of the thorax, the flocculation test for syphilis and urinalyses all gave negative results. The concentration of hemoglobin was 12.3 Gm. per 100 cc. of blood and leukocytes numbered 11,600 in each cubic millimeter of blood. Surgical treatment was advised and accepted.

On July 22, 1944, the patient was operated upon while she was under nitrous oxide, oxygen and ether anesthesia. The anesthetic agents were administered through an intratracheal

tube. An incision was made around the circumference of the growth in such a manner as to preserve all possible healthy appearing and nonadherent skin. After the subcutaneous tissues and platysma muscle had been incised, the tumor was retracted upwards and medially. The internal, common and external carotid arteries, the vagus nerve and the internal jugular vein were identified and isolated. The tumor was then removed. During the resection it was necessary to sacrifice the lingual, external maxillary and facial arteries, the posterior belly of the digastric muscle and a portion of the sternocleidomastoid and omohyoid muscles. We had anticipated having to excise most of the facial nerve and had so informed the patient but at operation it was found that we could dissect well around the tumor and into apparently normal tissue of the parotid gland without disturbing any of the major divisions of this nerve. At the conclusion of the procedure 2 Gm. of sulfathiazole were dusted into the incision and a small strip of plain gauze was inserted as a drain. A small plastic procedure facilitated satisfactory approximation of the skin flaps.

Postoperatively, it was evident that there was weakness of the small facial muscles at the angle of the mouth on the left side due to interruption of the small inframandibular twig of the seventh cranial nerve. This has persisted but has caused the patient very little inconvenience. Convalescence was otherwise essentially satisfactory. The patient left the hospital on the eleventh postoperative day and was subsequently rehospitalized for three additional days for radium therapy to the operative site. She was dismissed from our care after satisfactory healing of the wound and in good general condition on August 15, 1944, twenty-four days after operation. She has remained well since. Figure 2C shows her postoperative appearance.

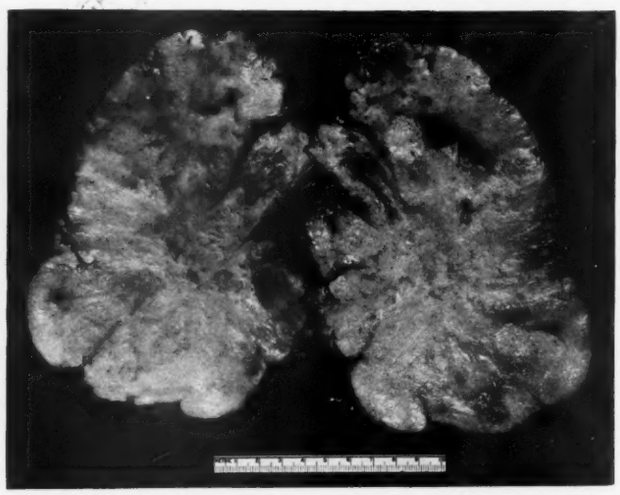

FIG. 3. Case II. Adenocarcinoma of the parotid gland of the mixed tumor type; weight 2,100 Gm.

Examination by the pathologist showed that the tumor weighed 2,100 Gm. It measured 20 by 14 by 12 cm. It was grayish white and of solid consistency with a few small cystic regions. (Fig. 3.) Histologically, it was an adenocarcinoma, grade 2 (Broders' method), of the mixed tumor type.

Comment on Case II. Most pathologists agree that mixed tumors of the parotid gland are almost invariably malignant. Usually they are adenocarcinomas of grades 1 or 2 according to Broders' classification. In spite of their histologically malignant appearance, however, they very rarely metastasize. Mixed tumors of the salivary glands frequently recur after removal and they may become locally invasive and occasionally involve the regional lymph nodes. Distant metastasis from these tumors is very uncommon, however. Only a few such cases have been recorded in the literature.[6] The tumor in the present case had been present for eighteen years and had grown to a very large size but still there was no discernible evidence of spread to regional lymph nodes or distant structures.

The first surgical problem in association with this case was the fashioning of adequate skin flaps. Much of the skin over the surface of the growth was thinned, atrophic, scarred and adherent to the tumor. It would have been unwise to attempt to save such skin. Its blood supply was very poor and, because it was adherent to the tumor, to have preserved it would have been to subject the patient to unnecessary risk of cutaneous recurrence in the future. Accordingly all the diseased skin was excised. In spite of this, primary closure of the incision was obtained without undue tension.

The next step in operating on patients of this type is to locate and isolate those structures in the neck which it is essential or highly desirable to preserve. Of prime importance is the avoidance of injury to the internal carotid artery. Interruption of this artery among adults often leads to hemiplegia and permanent damage to the brain. It is safer to ligate the common carotid artery than the internal carotid, for when the common carotid is ligated the internal branch receives some collateral circulation via the external carotid artery. Other structures which it is highly desirable to preserve include the external and common carotid arteries, the vagus nerve and the ansa hypoglossi. The internal and external jugular veins, as well as the superior thyroid, lingual and external maxillary arteries and other branches of the external carotid arteries, may be sacrificed without apparent deleterious effect. The facial nerve should be preserved if possible. It is fairly frequently necessary to remove portions of some of the branches of this nerve in order to obtain complete removal of the tumor. This is more often necessary when the parotid tumor is large or recurrent than in other instances. In the present case it was gratifying to find that the seventh nerve could be left intact except for the small inframandibular branch which controls the small muscles at the angle of the mouth.

After the essential structures are isolated the tumor is usually easily removed. Perfect hemostasis and skin suture complete the task.

Postoperative local radium therapy, such as was given in this case, is probably advisable for most mixed tumors of the parotid gland. Recurrent growths sometimes occur after apparently complete surgical removal. Radium therapy may minimize this tendency. It used to be customary to swab out the bed of the tumor with a caustic solution at the completion of the operation in an attempt to destroy any residual malignant cells. Harrington's solution was commonly employed.[7] This obviously has deleterious effects on the surrounding normal cells as well as on the tumor cells and may delay healing of the incision. At the present time it would seem that properly applied radium therapy will be more effective in destroying any residual neoplastic cells than any other form of treatment. It is probably true, however, that if complete surgical extirpation is not obtained other forms of therapy will simply delay and not prevent recurrences.

SUMMARY

Two cases of unusually large tumors of the neck are presented. The first tumor was a hyperfunctioning adenomatous goiter, which weighed 1,075 Gm. The second was an adenocarcinoma of the parotid gland of the mixed tumor type, which weighed 2,100 Gm.

In the surgical management of large cervical tumors adequate exposure is essential. In removal of large goiters the trachea should be located in order to facilitate tracheotomy if that becomes necessary. If part of the goiter is intrathoracic, the superior pole of the thyroid and the superior thyroid vessels should be isolated, doubly ligated and divided before one attempts to elevate the intrathoracic portion. The dead space left by removal of the goiter should be drained with a strip of finely woven gauze.

Mixed tumors of the parotid gland are almost invariably malignant histologically

but rarely metastasize. In the removal of large parotid tumors avoidance of injury to the internal carotid artery is of prime importance. It is safer to ligate the common carotid artery than the internal carotid. The facial nerve should be preserved if possible. Postoperative radium therapy is advisable.

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Neck dissection for removal of diseased lymph nodes may be indicated in Hodgkin's disease, tuberculous adenitis, primary endothelioma, metastatic carcinoma, carcinoma arising from a branchial cleft, and rarely for lymphosarcoma and tumors of the carotid body. This dissection depends upon the extent and character of the disease.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

PENICILLIN TREATMENT OF GAS GANGRENE*

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THE value of penicillin in the treatment of gas gangrene infections has been established experimentally,[1,2] and favorable clinical reports have been published in American literature.[3,4] Lyons[5] has stressed the necessity of the local use of penicillin in addition to systemic therapy. Kepl[3] has reported two cases and McKnight[4] reported one case in which penicillin was used locally and intravenously with good results. Specific antiserum was also used in these cases.

From extensive experience with experimental gas gangrene infections in dogs, Dowdy[2] has reported favorable results using sulfadiazine both as a prophylactic and therapeutic measure against most of the pathogenic Clostridium organisms except Clostridium novyi. The latter organism was affected little or not at all. Penicillin, on the other hand, was found to be very effective against all the Clostridium goup used, if therapy was begun before the infection was too far advanced. Polyvalent antiserum was also favorably reported in this series, and the combination of sulfadiazine, penicillin, and antiserum was recommended as the most effective therapy of severe cases, along with adequate surgery.

The difficulties in the clinical application of experimentally established data are well recognized. Numerous clinical studies attest to the lack of favorable results in the treatment of gas gangrene with antiserum and sulfadiazine, which these experimental findings would lead one to expect. The encouraging reports of the usefulness of penicillin in this infection have as yet not been established by sufficient clinical trial.

Three cases are presented below in detail which seem to indicate the favorable effect of penicillin on clinical gas gangrene infections. None of these patients received antiserum. One of them (Case II) received systemic penicillin and local surgery without sulfonamide therapy. The two others received sulfamerazine and penicillin. In only one of our cases was any amputation necessary, and this was done in the course of a thorough débridement of completely necrotic tissues of the foot. This amputation of the toes was not an effort to amputate above the infection but was necessitated by an inadequate local blood supply to the part.

In all three cases the rapidly spreading infection, with crepitation and characteristic black, liquefying necrosis of the muscles involved, left no doubt of the presence of a gas gangrene infection. In all three cases the presence of a Clostridium organism was established by finding a Gram-positive bacillus which formed gas in anaerobic culture. While by far the majority of such cases in civilian life are caused primarily by Clostridium Welchii infections, unfortunately in none of these cases were we able to obtain sufficiently pure cultures to identify postively which member of this group was present. The difficulties of this bacteriological procedure in ordinary hospital laboratories has been repeatedly stressed.[2,6]

CASE REPORTS

CASE I. (Fig. 1.) C. B., a thirty-year old Negro man entered the Belle Glade Migratory Labor Hospital on May 9, 1944, complaining of a swollen scrotum. Since 1937, he had noticed progressive difficulty of urination, and almost

* From the Migratory Labor Hospital, Belle Glade, Florida.

continual purulent urethral discharge. The present attack began five days before admission with a painful swelling of the right testicle.

In 1942 he took anti-syphilitic injections for two months.

Examination on admission revealed an under-

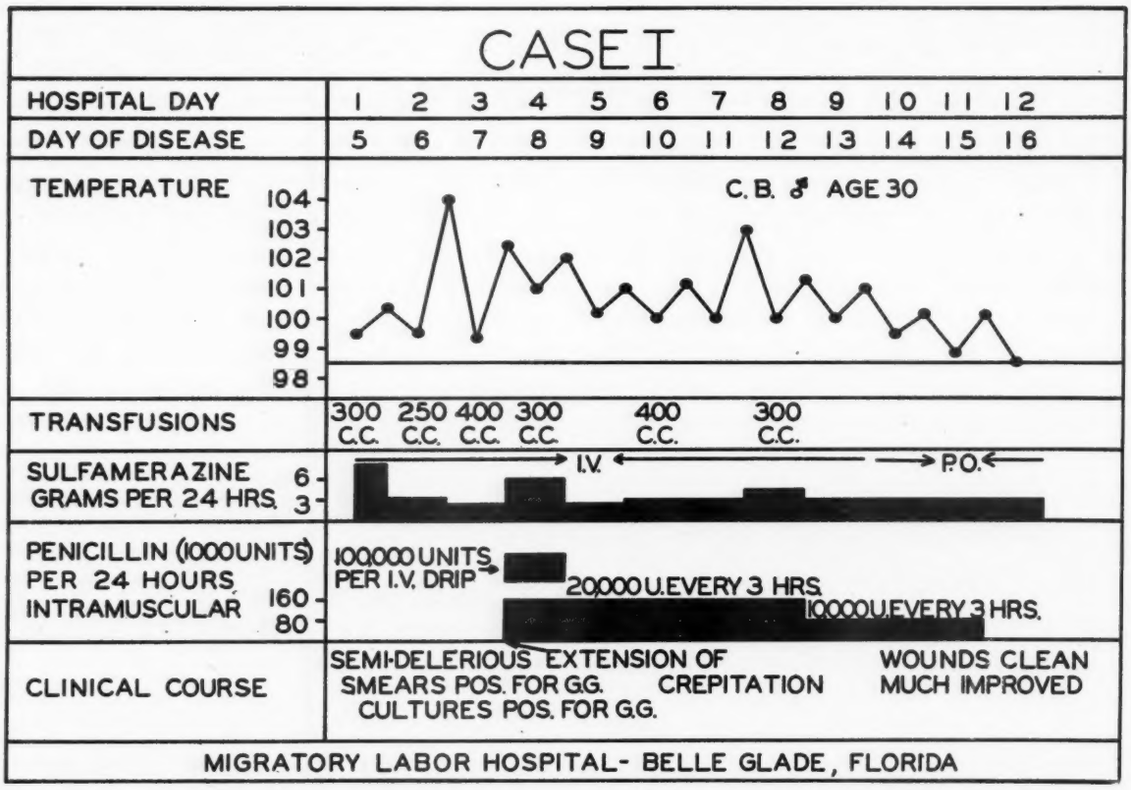

FIG. 1.

A B C

FIG. 2 Case 1. A, this picture taken three days after extensive incisions were made indicates the extent of the subcutaneous crepitation. The skin of the scrotum has completely sloughed away. A suprapubic tube is in place. B, twenty-five days later most of the incisions have healed and healthy granulations appear on the anterior abdominal wall and scrotum. A retention catheter is shown in a posterior urethrostomy. C, the skin grafts of the anterior abdominal wall were successful despite seepage of urine through the open cystostomy shown.

The swelling progressed to involve the entire scrotum, and he had increasing difficulty of urination. He had had a high fever with numerous chills for the past four days.

nourished, prostrate Negro man, with a high fever, appearing gravely ill and semi-delirious. The temperature was 104°F. and the pulse 140. Except for a generalized non-tender

lymphadenopathy the significant physical findings were limited to the scrotum which was symmetrically swollen to 12 by 15 by 10 cm. entire abdominal wall, and subcutaneous crepitation extended up toward the left axilla as high as the seventh intercostal space and

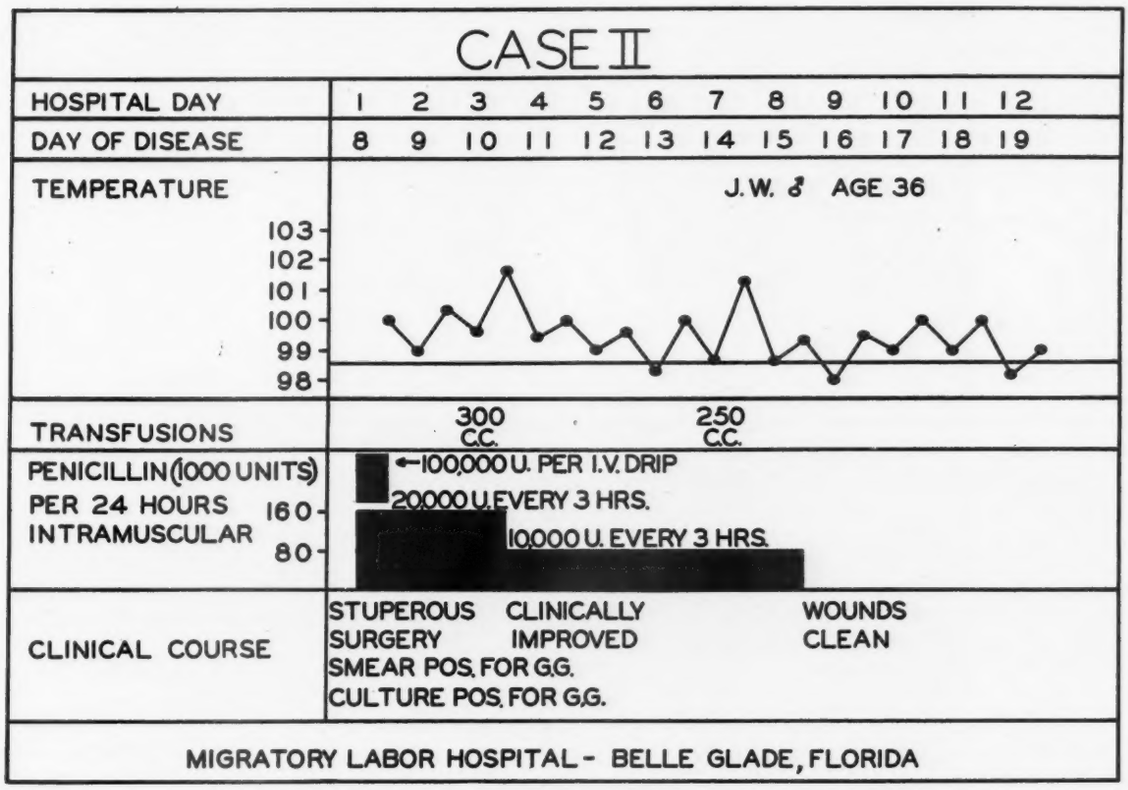

Fig. 3.

Several areas of the skin over the scrotum were gangrenous, and there was a very foul penetrating odor. Pitting edema was present just above the symphysis pubis, and the glans penis was deformed from old ulcer scars. Light probing with a filiform sound revealed an impassible stricture of the posterior urethra. The diagnosis on admission was posterior urethral stricture with urinary extravasation.

Sodium sulfamerazine and fluids were begun intravenously, and a suprapubic cystostomy was done shortly after admission, following which the scrotum was drained by "tiger claw" incisions. The extensive black liquefying necrosis of the scrotal structures suggested gas gangrene infection, and cultures and smears were taken. The smears showed a mixed infection containing short, blunt Gram-positive rods which showed definite gas formation after twelve hours anaerobic culture. These findings are consistent with the Clostridium group of bacilli. Twenty-four hours later there was extension of the liquefying necrosis over the downward over the upper half of the left thigh. The suprapubic incision was grossly infected and had to be reopened widely. There was marked abdominal distention and vomiting with absent peristalsis suggestive of peritoneal involvement. There was phlebitis of the left femoral veins with massive edema of the left thigh and leg. This spread occurred despite adequate functioning of the suprapubic tube. Extensive incision and drainage was done, as shown in Figure 2A, and 1 per cent hydrogen peroxide irrigation begun through Dakin's tubes sutured in the wounds. Penicillin was begun forty-eight hours after admission, and 100,000 units were given by slow intravenous drip during the first twenty-four hours along with 20,000 units given every three hours intramuscularly. The total dose for the first twenty-four hours was 260,000 units. During the next four days 20,000 units were given intramuscularly every three hours, and then reduced 10,000 units every three hours for

three days more. A total of 1,200,000 units were used.

There was no further extension of the infection, and general improvement was noticeable at the end of the third day. Healthy red granulations appeared promptly. (Fig. 2B.)

The entire skin of the scrotum and much of the anterior abdominal wall sloughed away and had to be skin grafted, which was done with results shown in Figure 2C.

The patient died four months later of causes unrelated to his gas gangrene infection.

CASE II. (Fig. 3.) J. W., a thirty-six-year old Negro Jamaican was admitted to the Belle Glade Migratory Labor Hospital on August 7, 1944, complaining of injury to both legs. Eight days prior to admission both feet were caught beneath a moving train. He had been treated elsewhere since the accident where sulfathiazole was given and a cast applied to the right leg. Examination on admission revealed an acutely ill, colored male, with a high fever, and a cast on the right leg below the knee. The left foot was discolored and obviously gangrenous to the mid-metatarsal level dorsally, and the entire volar aspect was a glistening black-green with subcutaneous crepitation. (Fig. 4A.) There was a very foul odor.

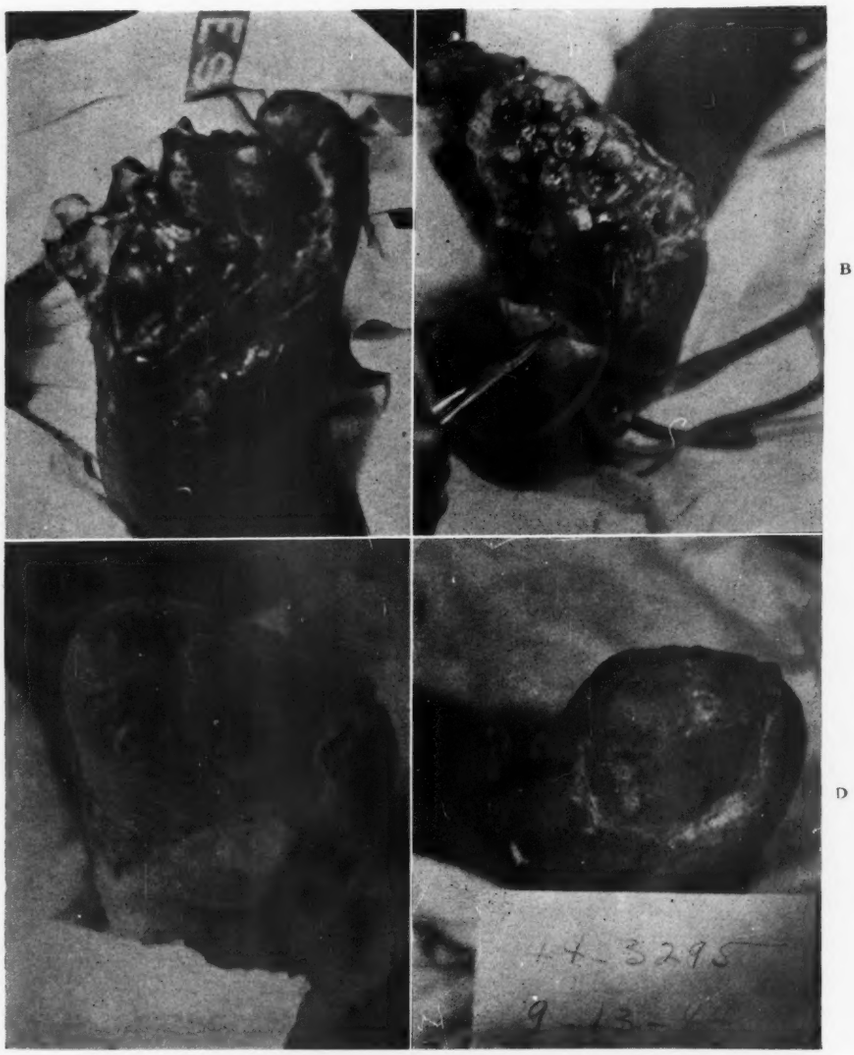

FIG. 4. Case II. A, the foot as it appeared on admission showing gangrene of the toes. The discoloration extends well up on the foot. B, this picture forty-eight hours after operation shows that the necrotic toes have been amputated and the volar aspect of the foot opened widely and débrided. Dakin's irrigation tubes are shown. C, the foot is shown twenty-two days after admission. Skin graft was done with satisfactory results shown in Figure 4D.

Fluids were given intravenously and a débridement done under spinal anesthesia. The toes were found to be completely devitalized and had to be amputated just proximal to the head of the metatarsal bones. The muscle bellies on the volar aspect were black and liquefied and had to be sacrificed well back beneath the calcaneous. (Fig. 4B.) Dakin's irrigation tubes were sutured in the wound, and 1 per cent hydrogen peroxide irrigations begun. Smears taken from the foot showed mixed infection, with numerous short Gram-positive rods with blunt ends, consistent with the Clostridium group of organisms. Anaerobic cultures showed gas formation in ten hours.

Penicillin was begun six hours after admission and 100,000 units were given slowly by intravenous drip during the first twenty-four hours along with 20,000 units intramuscularly every three hours. The total dosage for the first twenty-four hours was 260,000 units. This intramuscular dose was continued for two days when it was reduced to 10,000 units every three hours for five days more. The total dose given was 1,000,000 units. No sulfonamide or specific antiserum was given.

There was definite clinical improvement in forty-eight hours, and in four days the foot had a remarkably healthy red granulating base. (Fig. 4C.) Split-thickness skin grafts were done with results shown in Figure 4D.

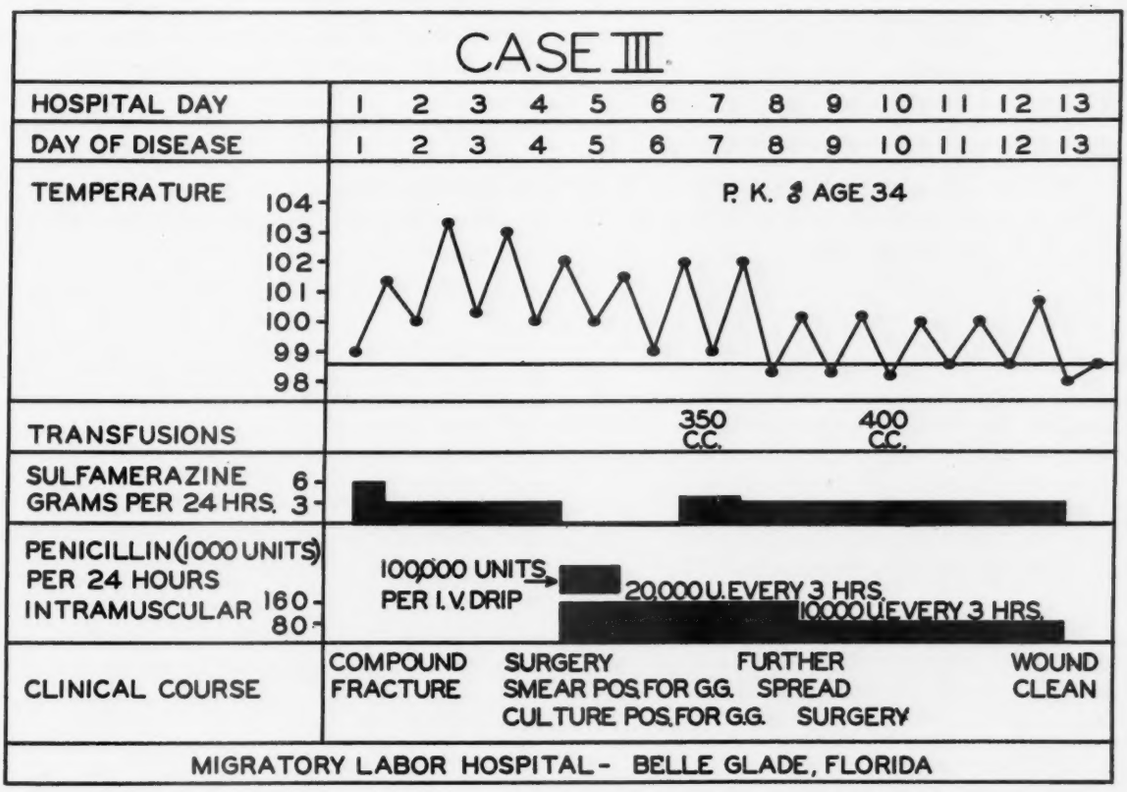
CASE III
HOSPITAL DAY 1 2 3 4 5 6 7 8 9 10 11 12 13
DAY OF DISEASE 1 2 3 4 5 6 7 8 9 10 11 12 13
TEMPERATURE
104
103
102
101
100
99
98
P. K. ♂ AGE 34
TRANSFUSIONS
350 C.C.
400 C.C.
SULFAMERAZINE GRAMS PER 24 HRS. 6 3
PENICILLIN (1000 UNITS) PER 24 HOURS INTRAMUSCULAR 160 80
100,000 UNITS PER I.V. DRIP
20,000 U. EVERY 3 HRS.
10,000 U. EVERY 3 HRS.
CLINICAL COURSE
COMPOUND FRACTURE
SURGERY SMEAR POS. FOR G.G. CULTURE POS. FOR G.G.
FURTHER SPREAD SURGERY
WOUND CLEAN
MIGRATORY LABOR HOSPITAL - BELLE GLADE, FLORIDA

Fig. 5.

Case III. (Fig. 5.) P. K., a thirty-four-year old Negro Jamaican was admitted to the Belle Glade Migratory Labor Hospital on September 4, 1944, three hours after having his left leg crushed beneath a tractor. On admission there was a severely compounded, comminuted fracture of the left tibia and fibula in their middle third.

The wounds were débrided and thoroughly irrigated with saline and sulfanilamide applied locally. Steinmann pins were placed through the tibia above and below the fracture, and the leg manipulated and a circular plaster cast applied. Mixed prophylactic antitetanus and gas gangrene serum were given on admission, and intravenous sulfamerazine begun. Forty-eight hours later the temperature was 103°F. and a window was cut in the cast revealing a glistening edema of the entire leg with local sloughing. A thick foul-smelling pus was discharging from the wounds. There was extensive subcutaneous crepitation. Smears from the pus

showed mixed infection with short Gram-positive rods, and in twelve hours the anaerobic cultures showed gas formation.

FIG. 6. Case III. This film shows the leg six days after the second operation. The granulations shown are fairly clean, and the edema has subsided.

"Tiger claw" type incisions were made and revealed a black liquefying necrosis of the muscle bellies, many of which had to be sacrificed. Dakin's tubes were sutured in the incisions and 1 per cent hydrogen peroxide irrigations begun. Penicillin was started the next morning and 100,000 units given intravenously by slow drip during the first twenty-four hours, with 20,000 units given intramuscularly every three hours. (The total penicillin given for first twenty-four hours was 260,000 units.) This intramuscular dose was continued for thirty-six hours when local spread of the crepitation upward was noted. More radical incisions were made, and further débridement of the necrotic deep muscles was done. Following this there was steady general improvement. No further spread occurred, and the incisions rapidly developed healthy granulations. (Fig. 6.)

The 20,000 units of penicillin was continued every three hours intramuscularly for two days and then reduced to 10,000 every three hours for five days. Total penicillin used was 1,000,000 units. Sulfamerazine was discontinued when the penicillin was started, but was begun again at the time of the second operation. Its value was questionable.

No antiserum was given except prophylactically, and no penicillin was used locally. Roentgenogram on September 18, 1944, revealed the changes of early osteomyelitis of the tibia.

SUMMARY

1. Three cases of gas gangrene in which the patients were treated with penicillin are presented. One of the patients received penicillin alone, and the other two sulfamerazine in addition.

2. Systemic penicillin without local application was used with satisfactory results in all patients.

3. In the cases presented the use of penicillin appeared to reduce the extent of radical surgery usually necessary.*

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* Med Scott Brown, M. T., made the bacteriological studies and drew the charts of the clinical courses of these cases.

PRIMARY ACTINOMYCOSIS OF THE LUNG*

WITH SECONDARY INVOLVEMENT OF THE KIDNEY AND BRAIN PRESENTING ABNORMAL PULSE AND TEMPERATURE REACTIONS

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THE causative organism of actinomycosis in man is Actinomyces bovis which is a fungus and one of the many microscopic members of the plant kingdom. It may be said in general that the plant kingdom consists of four major groups: the thalli, the mosses, the ferns and the seed plants. The thalli may be further divided into algae and fungi depending upon the presence or absence of chlorophyll. Algae, because they contain chlorophyll, may carry on a free and independent existence. Fungi, however, lack this very important substance and, therefore, are either parasitic, living on other organisms or saprophytic, living on the dead remains of other organisms.

Mycotic diseases of man may be superficial or deep seated. The superficial infections or dermatomycosis are due to the dermatophytes and may be classified as Microsporon, Epidermophyton, Trichophyton and Monilia. The deep seated infections are due to Actinomyces, Sporotrichum, Blastomyces, Coccidiodides and Phialophora and are characterized essentially by granulomatous reactions. Any of these might cause primary fungus infections in those who till the soil or who contact plants, hay, hay-straw, animals or their by-products, feathers, silk, wool and leather.

Superficial fungus infections are acquired by those who tend and care for pets, swimming pools and bath house attendants, dairymen and herders, bakers, preserve packers, fruit handlers and dishwaters. The deep seated infections are usually found in tillers of the soil, cattlemen, florists, horticulturists, wood-handlers and research workers.

Actinomycosis in man was first reported by Israel in 1878 and since that time has been observed with increasing frequency.

The occurrence of actinomycosis in the human, according to Cullen and Gross, is seen most frequently in the region of the face, jaw or neck, comprising 60 per cent of instances. About 20 per cent of occurrences are found in the abdominal cavity particularly in relation to the cecum or appendix or the adjacent abdominal wall. In the next 15 per cent of instances the primary focus is in the bronchial tree, the pulmonary tissue and the chest wall. The remaining 5 per cent are confined to the skin or other viscera.

In the generalized forms of actinomycosis the primary lesion in the majority of instances is found in the lung. The most noteworthy fact in regard to the primary lesion is that it may be so small as to be missed entirely. It is frequently missed in the roentgenogram made of the chest. Likewise it is commonly overlooked at autopsy even at the hands of the most skilled pathologist.

Metastatic lesions may be few or may involve many organs. The brain and the kidney head the list of most frequent sites of involvement.

The clinical course frequently presents a disease of marked chronicity in which the symptoms of malaise, fatigue, low grade fever and weight loss may be so lacking in importance as to disarm the clinician completely. It is only after the symptoms referable to the infected organs become sufficiently prominent and after the most exhausting diagnostic procedures are carried out that the true nature of the illness may be suspected only to be later con-

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firmed, after operation or at the autopsy table.

Attention is directed to the problem which is sometimes posed for the surgeon. Since many of the reported cases of actinomycosis of the kidney also had involvement of the brain, all of course terminated in death. Thus there is presented for the surgeon the most difficult and vexing problem of whether or not to operate in some of these puzzling cases.

It is imperative that the most painstaking study be made in order that all avenues of infection be thoroughly explored before deciding on a course of action.

Human nature being what it is, it is doubtful if an autopsy would have been permitted in the case here reported had surgery of the kidney been attempted.

The following case report is submitted not because it presents anything new, but rather to re-emphasize the importance of keeping in mind the possibility of actinomycosis in cases which are shrouded in obscurity and in which the symptoms are vague and inconclusive.

CASE REPORT

A white male, age forty-four, a carpenter, was first seen during his last illness on February 13, 1943, stating that he had worked only one-half day in February and that he felt tired all the time and had a slight headache. These minor symptoms comprised the sole subjective findings until one week later he began to feel a slight tenderness in the region of the left kidney. The fact in his past history worthy of note was that he had four attacks of penumonia during his lifetime, three in the past four years, the last one occurring in December, 1942.

On February 19, 1943, despite the apparent minor character of his complaints his general appearance had changed so much for the worse that intensive investigation was instigated. The blood Wassermann and blood cultures were negative. Also negative were agglutination tests for typhoid and undulant fevers. A second blood culture was negative. Urine was negative except for a faint trace of albumin.

By February 23, 1943, a definite renal tenderness on the left side could be elicited. The patient was hospitalized and a urological study made.

Examination at the hospital preliminary to a cystoscopic study revealed a temperature range of 97 to 99.2°F., heart rate 60 to 72, blood pressure 120/70. Urine contained a large amount of pus cells, four plus sugar and a heavy trace of albumin.

Blood examination: white blood cells, 28,600. red blood cells, 5,150,000, hemoglobin 95 per cent, blood urea was 14 mg. per 100 cc.

Roentgenogram of the chest revealed infiltration at the root of the right lung, involving particularly the pulmonary tissue adjacent to the larger truncal markings of the inferior bronchial tree. The heart appeared to be moderatedly enlarged in the ventricular diameter.

Roentgenogram of the kidney, ureter and bladder revealed both kidneys to be enlarged, the one on the left being considerably larger.

Intravenous urogram showed both kidneys to be excreting actively. There was no marked deviation of the renal pelvis from the normal except for some blunting of the calices of the left kidney. The left kidney did not move on respiration.

On February 26, 1943, a cystoscopic examination was performed. At the time of this examination the patient appeared gravely ill. He hiccoughed continuously. There was marked restlessness with rolling of the eyes and an apparent inability to see objects clearly. There was a suggestion of stiffness of the muscles of the neck and muscular resistance over the left kidney. At this time the temperature range was from 98.6 to 100.2°F. The pulse range was notable, varying from 60 to 72.

Cystoscopic examination revealed a fairly normal appearing bladder containing heavy pus laden urine. Both ureters were catheterized with No. 6 catheters. Indigo carmine administered intravenously appeared promptly in good concentration from both kidneys. The urine from the left side was grossly pus laden and on culture showed a growth of staphylococci. The type was not determined.

On the basis of the findings a diagnosis of left pyelonephritis with perirenal involvement was made.

The most difficult problem in this confusing case was to arrive at a decision of whether to perform an operation at once or to defer it until a later time.

Because of inconsistencies and confusion in the clinical picture due to the presence of a persistent low fever range and of a low pulse rate which at times dropped to 56 per minute, the persistent hiccough, the visual disturbance, the restlessness and the disorientation and a detectable stiffness of the muscles of the neck and back, operation was deferred to await further clarification of this case. The wisdom of the decision not to operate was borne out by subsequent events.

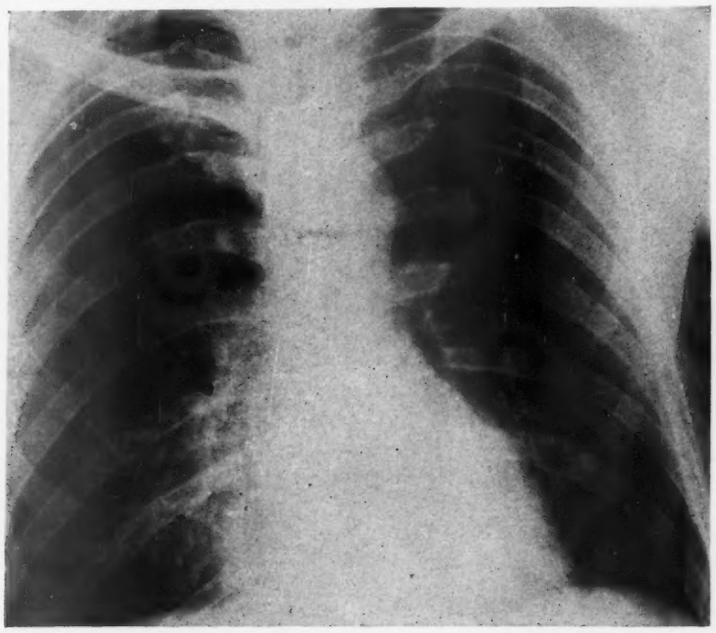

Fig. 1. This photograph of the roentgenogram of the chest revealed only changes that would be expected in a man who had had several attacks of severe respiratory infection. At autopsy the primary focus was found in the region indicated by the arrow.

Spinal taps made on successive days showed the spinal fluid to be under increased pressure and the cell count varied from 350 to 700 cells per cc. Culture of the spinal fluid was negative.

It was concluded from the findings that we were dealing with a perinephritis infection and an involvement of the meninges. Because there was no history of any preceding infection and because the roentgenogram of the chest showed only changes that one would expect to find in any chest of a man who had had several severe respiratory infections, it was believed that the primary infection was in the kidney with a secondary meningitis.

Despite all efforts to improve the patient's condition he rapidly became worse and death ensued on the eleventh day in the hospital.

An autopsy was performed by the hospital staff pathologist. The report is as follows:

The body is that of a tall white male, adult. It is well developed though slightly thin. There is no enlargement of the lumph nodes or thyroid. The external genitalia are normal.

There are a few adhesions to the right lung. There is no consolidation. A small firm indurated area is present in the lower anterior border of the right lung. The heart is of normal size. The muscles, vessels, and coronary arteries are not remarkable. The mediastinum is normal.

There is no peritonitis. The viscera are properly situated. The liver and gallbladder show nothing of note. Pancreas and spleen and gastrointestinal tract are essentially normal. The bladder is distended two and one-half inches above the pubic arch. It is filled with clear urine and shows nothing else of note. The prostate is normal; the ureters are also normal. The left kidney is large and distorted. There is a collection of pus outside the capsule of the upper outer third. An adjacent abscess is found in the kidney cortex ($2\frac{1}{2}$ cm.). This has a ragged necrotic lining. The pus has a greenish-yellow color. The right kidney shows nothing remarkable. It is fairly firm, but has a slightly reddish color. The adrenal glands are normal.

The scalp and skull are negative. The cerebral convolutions are flat and wide and have a pale yellow color. There is some greenish purulent exudate at the base and about the

outlets of the fourth ventricle. There are several abscess pockets in the right frontal lobe. These measure up to 2 cm. in diameter. They contain greenish pus. The ventricles contain a large amount of thin green exudate. This is very marked in the fourth ventricle.

The sections of the brain were taken from the abscess area. They show granulamatous infection with suppuration. Numerous giant cells of Langhans' type are noted. Similar inflammatory reaction is noted in the ependyma and pia.

The section of the lung is from the indurated area described in the gross. It shows an inflammatory process similar to that described in the brain. There is no suppuration. However, the process is more of a granuloma with considerable fibrosis and atelectasis. Giant cells of the same type are noted here also.

The kidney section shows a large area of suppuration and necrosis with very abundant giant cells, and it seems to be well demonstrated that a similar type of infection is present in all of these areas studied. Smears of the pus show the presence of branching filamentous Gram-positive bacilli of the streptothrix or actinomyces type. This is probably in Actinomyces asteriodes.

FIG. 2. Photograph of the roentgenogram of the kidney area showed both kidneys to be larger than normal with the most pronounced enlargement on the right side. This kidney was found to be normal at cystoscopic examination and confirmed at autopsy.

FIG. 3. Intravenous urogram shows both kidneys functioning actively and apparently to an equal degree. The catheterized specimen of urine from the left kidney was grossly infected with staphylococci. Despite this infection the function of the kidney was equal to that of the healthy right kidney. Autopsy revealed the left kidney and brain to be the sites of metastatic infections of actinomycosis.

Diagnosis: Perirenal and renal abscesses (left kidney); cerebral abscesses; chronic granuloma of the right lung.

This is an unusual infection and is probably primary in the lung.

Comment. The findings at autopsy probably revealed the real cause for the confusing clinical inconsistencies of a pulse rate range which at times dropped to 56 and a fever range which varied from subnormal to no more than 100 despite the

fact that the white blood cell count was consistently over 28,000 throughout the illness.

It is generally accepted that the body temperature is regulated partly by a thermostat-like control located in the region of the thalmus. Clinical observation and experimental evidence show that diseases of the brain caused by hemorrhage, tumor, meningitis or trauma are likely to be associated with rapid oscillations in the body temperature.

The auricular muscles, the sino-auricular node, the atrioventricular node and perhaps the larger part of the bundle of His are under the direct control of the cardio-inhibitory fibers of the vagus nerve whose nucleus is situated near the floor of the fourth ventricle. The rate of impulse formation in the pace-maker or lowering of the rate of impulse formation in the sino-auricular node reduces the heart rate. Increased intracranial pressure from tumor or the accumulation of exudate in the basal meninges may produce a persistent bradycardia. In such instances the pulse rate or the changes of body temperature or both, may not normally vary with changes in the degree of systemic infection.

It is believed that on a pathophysiological basis the abscesses in the region of the thalmus and the fourth ventricles disrupted the normal fever producing function of the temperature regulating center and at the same time disturbed the nucleus of the vagus causing a bradycardia. This offers a reasonable explanation of the baffling inconsistencies of a low fever and a subnormal pulse rate in a patient who had an infection of such severity as to terminate in death.

CONCLUSIONS

In diseases of marked chronicity in which malaise, ease of fatigue, low grade fever and loss of weight are the presenting symptoms, actinomycosis should be considered.

When any symptom complex presents inconsistencies of temperature and pulse range wholly at variance with the obvious severity of the illness, together with vague mental symptoms, the finger of suspicion should point toward involvement of the structures of the base of the brain.

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LONGITUDINAL FRACTURE OF THE HEAD OF THE FEMUR ASSOCIATED WITH DISLOCATION OF THE FEMUR

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THE head of the femur is protected from direct injury because of its deep seated position in the acetabulum. When the force of impact is in direct line with the neck of the femur, it may be crushed by the impact or protruded into the acetabulum. Any force at right angles to the neck will produce a sub-capital or other type of fracture of the neck of the femur. When a dislocation of the head of the femur occurs the femoral head is rarely injured because of its firm covering of articular cartilage. The acetabular margins are frequently torn off or there may be a small chipping fracture of the head. A longitudinal fracture involving a third or more of the head is relatively rare. Little information is given in the standard textbooks on fractures and few cases are reported in the literature. Watson-Jones gives a short paragraph in his textbook on fractures. From personal communications of J. M. Murray, J. Warren White and Austin Moore, who have had one or more cases, we are inclined to believe that if a complete survey were made, a considerable number of longitudinal fractures could be gathered together and some valuable data obtained about this clinical entity.

The mechanism of the production of a longitudinal fracture is speculative and may depend on a number of factors. Usually it is associated with other injuries and due to a considerable force, as a fall from a height or automobile collision. Just why the head should split longitudinally may depend on a number of factors. The relative size of the head and its relation to the acetabulum may be important; as when the head is large and not deep seated in the acetabulum so that a considerable portion protrudes laterally from the acetabulum. The relative density of the head and acetabulum, the angle of the neck with the shaft and the amount of antiversion may be influencing factors. The position of the extremity at the time of the injury, whether in adduction or abduction, internal or external rotation may be a contributing factor.

The diagnosis of a fracture in association with the dislocation can only be made from the roentgenogram, as the physical findings do not differ from those of a simple dislocation.

The prognosis for a normal functioning hip, after a longitudinal fracture with dislocation, is not very good and should be guarded. Even if the dislocation is reduced accurate apposition of the half head with the fragment in the acetabulum is difficult. If good apposition is obtained, union may not result; and even should it take place, late aseptic necrosis with dissolution of the head may occur. Furthermore, loss of strength, limitation of motion and a painful hip are possibilities.

The treatment of a longitudinal fracture of the head of the femur with dislocation is difficult because of the possibility of the previously mentioned complications. It may be treated by a closed or open operation.

Primary closed reduction should first be tried utilizing the standard procedures of simple dislocation at the hip joint. Preliminary skin or skeletal traction may be helpful. If a successful reduction with apposition of the fragments is secured, immobilization by a plaster spica is instituted until union is obtained, which may be considerably delayed because of circulatory disturbances. Because of the lack of reported cases no data can be given relative to the late results, but the possi-

bilities of aseptic necrosis must always be considered.

If the attempt at closed reduction is not successful, one must resort to open operation. Either the anterior or posterior approach may be utilized. If the posterior approach is made, one can determine more accurately the condition of the posterior rim of the acetabulum. There are four main alternative methods of treating the dislocation: (1) Reduction of the portion of the head into the acetabulum and approximating it to the remaining portion in the acetabulum; (2) reduction of the head after first removing the piece in the acetabulum; (3) removing the part of the head from the neck and after removal of the piece from the acetabulum, performing a reconstruction operation, either according to the Whitman, Colonna or Albee type of operation; (4) arthrodesis of the remaining part of the head and neck into the acetabulum. The decision as to which type of procedure to adopt may depend on a number of factors. The age of the patient, sex, type of work to be performed, economical factors, whether one wishes only one operation, and if only one, the type that will be definitely free from the possibility of a painless extremity. Keeping in mind the previously mentioned possibilities of failure of union, of late aseptic necrosis, possibility of a painful movable hip and recurring deformity, an arthodesis offers the best chance to obtain a satisfactory result with only one operation. If mobility is important or desired, reposition with or without approximation of the two fragments or a reconstruction operation should be performed, reserving arthrodesis for a later procedure.

Fig. 1. Longitudinal fracture of the head of the femur with dislocation; free fragment in acetabulum. (In this instance, negative of picture has been reversed.)

The report of the history and procedure on one patient with longitudinal fracture of the head of the femur with dislocation will serve as an example and bring forth some of the problems that one may encounter. It may also help to form some conclusion as to the best type of procedure to institute in the treatment of this lesion.

FIG. 2. After excision of the fragment from the acetabulum and reduction of the remainder of the head.

CASE REPORT

R. M., age forty-three, a roof worker, fell from a second story roof landing onto the pavement on April 16, 1943. In addition to a longitudinal fracture with dislocation of the head of the right femur, he sustained numerous other injuries which will be mentioned as they had some influence on determining the type of treatment. There was a very severely comminuted fracture of the upper end of the left tibia and fibula with displacement of the fibula and part of the tibia, fracture and dislocation of the metatarsals of the right foot, fracture and dislocation of the scaphoid of the left foot, and dislocation of the left humerus.

The patient was in fairly good condition when first seen. It suffices to say that the various injuries aside from the one under discussion were taken care of by appropriate methods in the convalescent period. There was a shortening of the right extremity. The leg was in external rotation. All movements were painful. The head of the femur was felt posteriorly. The roentgenogram showed the head of the femur split in half and dislocated. (Fig. 1.) The remaining portion was in the acetabulum. There was no fracture seen about the rim of the acetabulum. An attempt to reduce the fracture dislocation of the right femur was unsuccessful. Skeletal traction was applied and after several days another attempt was made to reduce the hip but it was unsuccessful. Open operation through a posterior approach was then performed. Because of the numerous other severe injuries and the necessity of not performing too many operations it was thought best to remove the portion of the head from the acetabulum and place the remainder of the dislocated head of the femur in the acetabulum. This portion of head was difficult to maintain at the time of the operation and did not sink in like an entire head usually does when reduced. This may have been due to the lack of the cohesive force exerted by an entirely

rounded head with the smooth surface of the acetabulum. (Fig. 2.) Later check showed a redislocation of reduced half head of the femur.

A second operation was performed and in attempting to place the head portion in the acetabulum it broke off. Then a decision was necessary as to whether to attempt an arthrodesing or a reconstruction operation. It was thought that an arthrodesis of the hip would be preferable as it would give him a stable hip and save him from the chance of another operation. It was also thought at the time that he would have a flail knee on the opposite side. There was a failure of bony union after this operation which in view of subsequent events appears to be fortunate. (Fig. 3.) He obtained a stable knee on the opposite side with limited motion in the knee joint on the side of the dislocation. The patient is at present able to walk with a cane. He had about 40 degrees of painless flexion in the right hip with about 10 degrees abduction and practically no rotation. He has only 80 degrees of motion in the right knee joint and 30 degrees in the left knee joint. If his trochanter had been transferred down or a bone lever operation been performed, he would have had greater stability of the right hip.

Fig. 3. Present condition after removal of remainder of the head and placing the neck of the femur in the acetabulum.

CONCLUSION

In general in longitudinal fracture with dislocation, closed reduction should be attempted. If reduction is not successful or good apposition of the fragments is obtained, open operation is necessary. Removal of the loose piece of the head fragment from the acetabulum and then reducing the half head may be tried. It may be preferable to remove the half head attached to the neck and perform a reconstruction operation according to the method of Whitman, Colonna or Albee.

Arthrodesis should be reserved for later painful hips. If only one operation is advisable an arthrodesis may be the procedure of choice if knee joints and opposite hip are not impaired.

FATAL PERITONITIS FROM PROCTOSALPINGOSTOMIC FISTULA COMPLICATING LYMPHOPATHIA VENEREUM*

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THIS case is notable for the circuitous route which the lethal rectal contents took before inducing the fatal termination of the case. We have been unable to find any record of a similar episode in the literature. The comprehensive Standard Classified Nomenclatures of Disease does not list any connection between the rectum and the Fallopian tube.

CASE REPORT

No. 5883, Mrs. M. M., a thirty-two year old negress, was admitted to the surgical service of Dr. John O. Bower at the Philadelphia General Hospital on March 29, 1939, because of diffuse abdominal pain and vomiting.

On March 24th, she developed pain in the left loin, radiating into the rectum. Despite a sensation of desire for defection, she was unable to move her bowels. The pain persisted, she took epsom salts on that day, and diarrhea occurred on March 25th. A physician ascribed her illness to "ovarian trouble" and administered an opiate. The following day she took an enema and simultaneously passed greenish feces and vomited greenish fluid. On March 27th, she vomited once. This occurred again the following day. During this time she had eaten only small quantities of food. On March 28th, she noted blood in her urine on one occasion. Leukorrhea was persistent. Her last menstrual period, lasting one day (usual for her), had occurred two weeks before.

In 1925, she had had a right salpingo-oophorectomy and appendectomy for chronic salpingitis. In 1926, a rectal stricture was dilated at the Philadephia General Hospital. It had produced symptoms previously for seven years. At this time the Wassermann was 4 plus and the Frei test positive. She had had typhoid fever at the age of eight. She stated that she had experienced two previous attacks of loin pain radiating down into the rectum, one in December, 1938, and the second in February, 1939. She thought she had lost weight but was not sure of the amount.

The picture was that of an acutely ill, thin negress with slightly icteric sclerae and dyspnea. Her skin was warm and dry. Temperature 102°F., pulse 128, respirations 140, blood pressure 116/70 were noted at 11:30 A.M. on the day of admission. Her eyes were prominent, and the pupils reacted poorly to light. Oral hygiene was poor. Her tongue was dry and coated white. Heart and lungs were normal. The abdomen was markedly distended and had a midline infra-umbilical scar. Tenderness was present in the entire lower abdomen, most marked on the right. Peristalsis was absent except for an occasional tinkle over the course of the descending colon. No masses were palpable. The bladder was not distended. The liver and spleen were not enlarged. Granulation tissue was present about the urethra. Leukorrhea of moderate degree was evident. A small buttonhole in the left labium communicated with the vagina on the same side. A finger-like projection, 2 cm. in length and 1 cm. in diameter, was seen on the anterior wall of the vagina just beneath the urethra. The cervix was smooth and firm. There was no pain on moving the uterus. No adnexal masses were palpable. The anterior rectal wall was greatly indurated as high up as the fingers in the vagina could reach. Rectal examination revealed a stricture about 2 inches above the cutaneous margin. This admitted the tip of the index finger.

The provisional diagnoses were: (1) Rectal stricture due to lymphopathia venereum. (2) peritonitis—pelvic and spreading—due to pelvic

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inflammatory disease; (3) syphilis—site undiagnosed. (4) hypochromic anemia; (5) urethral caruncle.

On admission her hemoglobin was 49 per cent, red count 2.16, and the white cell count was 20,200 (M-8, J-14, St-62, Seg-12, L-4, Monos-8).

Perforation of the bowel was considered likely and the patient was placed on an Ochsner regime and Wangensteen suction instituted. She was given 2,450 cc. of fluid by hypodermoclysis in the first eighteen hours. On March 30th, 150 cc. of blood, 40 cc. of lyophilized convalescent peritonitis serum, and 4,250 cc. of parenteral fluids were administered. Her hemoglobin was 45 per cent, red blood count 2.10, white blood count 19,700 (M-0, J-2, St-70, Seg-6, L-12, Mono-0). Urine analysis at this time demonstrated 2 plus albumin, 2 plus leukocytes, 1 plus red cells, and granular casts. Flat plate of the abdomen on March 29th revealed a paralytic ileus with no definite evidence of obstruction. On March 31st, her blood sugar was 180 mg. (intravenous glucose given concomitantly), urea 10, plasma chlorides 646, and carbon dioxide combining power 37. On April 1st, signs of consolidation in the left base appeared. Her respirations were 50 to 65 per minute. The next day consolidations developed in the other base. Distention was unchanged and peristalsis absent. Fluids were given parenterally, only. Her temperature fluctuated between 100 and 106°F. and the pulse varied from 90 to 150. At 9:30 A.M. on April 2, 1939, she expired.

Autopsy was performed by Dr. W. Erich twenty-eight hours after death. Bilateral, moderate hydrothorax and pleural adhesions of the left upper lobe were present. Both lungs were markedly edematous and a small embolus was evident in the right lower lobe. The heart demonstrated acute toxic degeneration. There was diffuse fibrino-purulent peritonitis. Right adenexae were absent. The spleen showed moderate pulpitis. The kidney and liver revealed acute toxic degeneration. The adrenals had lipoid depletion. The pelvic veins showed thrombosis. Old adhesions of the uterus and left adnexae were present. The rectum revealed advanced lymphogranuloma with a stricture two inches above the skin margin. Careful dissection demonstrated a fistula between the left side of the rectum, just above a stricture, and the left Fallopian tube near the ampulla (Fig. 1.) The uterine end of the tube was occluded.

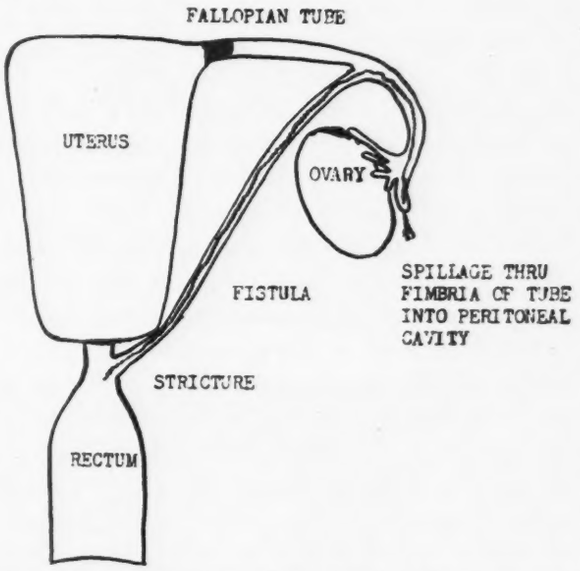

Fig. 1. Proctosalpingostomic fistula (diagrammatic) with extravasation of rectal contents through tract in left broad ligament into left Fallopian tube and into peritoneal cavity.

COMMENT

The concomitant presence of syphilis, gonorrhea, and lymphopathia venereum is frequently seen in clinics with a large negro clientele. The added spice of chancroid, Vincent's genital infection, granuloma venereum, venereal warts, or herpes is not uncommon. Lymphopathia is seen most in the years of greatest sexual alacrity. Its sexual distribution is about equal, but the haven of treatment for each of the sexes is different. The forlorn male with bubos is projected to the genitourinary dispensary by even the most naïve social service maiden, whereas the female is assigned to the proctologist or general surgeon for her presenting rectal symptoms. The incidence of rectal stricture has been shown to be higher in the female. In twenty series' summaries, the ratio varied from 1.4:1 to 30:1. The mean ratio is probably above 3:1. The statistics in this country have shown an overwhelming predominance in the colored race. The data of European investigators have been collected from white patients. Hayes[1] collected 168 cases of

which 116 were in negresses, ten in negros, thirteen in white males, and seventeen in white females. In the majority of cases, the stricture lies between one and three inches above the anus.

A case which may have been similar was recorded by J. Couper[2] in 1870. He told of an autopsy in a patient with a rectal stricture of five years' duration, situated three one-half inches above the anus, "due to pus from an ovarian abscess finding its way into the rectum at (below) the seat of the stricture, and also making its escape by several sinuses running beside the bowel and opening on the buttock." No mention of a fistulous tract was made. Lancereaux,[3] in 1859, was the first to present the picture of pelvic inflammatory disease together with stricture of the rectum. He thought that the rectal lesion was due to syphilis and the condition in the female adnexae a manifestation of gonorrhea. It is quite likely that the latter is correct, but the proctologic lesion was more probably lymphogranulomatous. Pelvic abscess and adnexal disease have been suggested as the cause of rectal stricture by many of the older writers; but in the light of newer investigation and observations earlier in the course of the process, it would seem that both are concomitantly secondary to a primary vaginal infection if patients with co-incidental gonorrheal pelvic disease are excluded. The affliction once so common among Mediterranean sailors who practiced pederasty may well have been primarily proctologic, though, Ravaut, Seneque, and Cachera[4] described patients with rectal stricture and chronic salpingoperimetritis, with or without vulvovaginal disease. Stannus[5] believed that a spreading pelvic cellulitis is part of the picture. David and Laurer[6] stated that laparotomy in some of the cases never revealed evidence of pelvic gland involvement. This is incompatible with the evidence showing the primary lesion in the vagina with later perirectal involvement by lymphatics from the lower part of the posterior vaginal plexus which run backward and pierce the rectal fascia. Therefore, the pathological process in the rectum then spreads toward the mucosa.

We believe that this presentation demonstrates the connection between lymphopathic disease of the rectum and its manifestations in the internal female genitalia. The production of a sinus tract from the stricture site in the rectum through the perirectal tissue and the broad ligament into the left Fallopian tube is a unique illustration of the manifold suppurative and fibroblastic components so characteristic of the disease.

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STAB WOUND OF THE HEART

SUCCESSFUL REPAIR OF A LACERATION OF THE HEART IN A PATIENT WITH AORTIC REGURGITATION AND MARKED CARDIAC HYPERTROPHY

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PITTSBURGH, PENNSYLVANIA

STAB wounds of the heart if not immediately fatal are offered a fair chance of recovery by prompt surgical intervention. Elkin in a series of forty-five patients with heart wounds had twenty-nine operative recoveries, none of whom had any residual symptoms referable to the injury. Bigger in a series of forty-five cases had twenty recoveries out of twenty-nine operative cases.

A rapid approach giving excellent exposure to the heart and pericardium, as well as the pleural cavity is obtained by an intercostal incision, the site depending upon the wound of entry and supplemented by division of one or more costal cartilages close to the sternum.

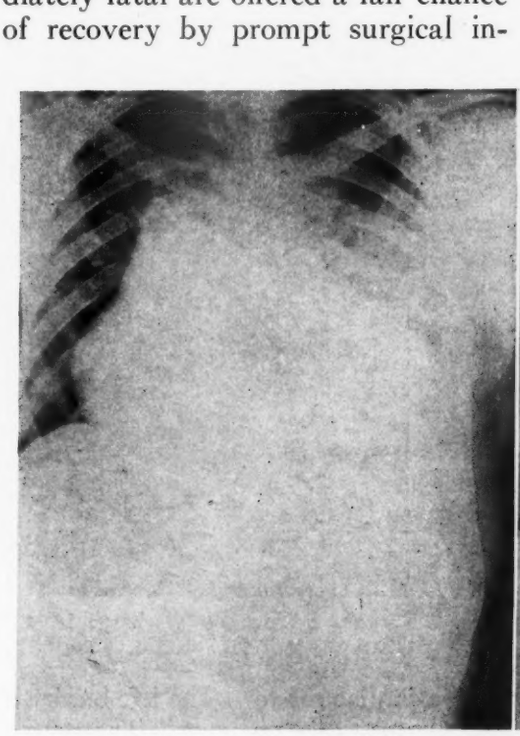

FIG. 1. Eight days postoperatively reveals a marked enlargement of the cardiac shadow suggesting pericardial effusion.

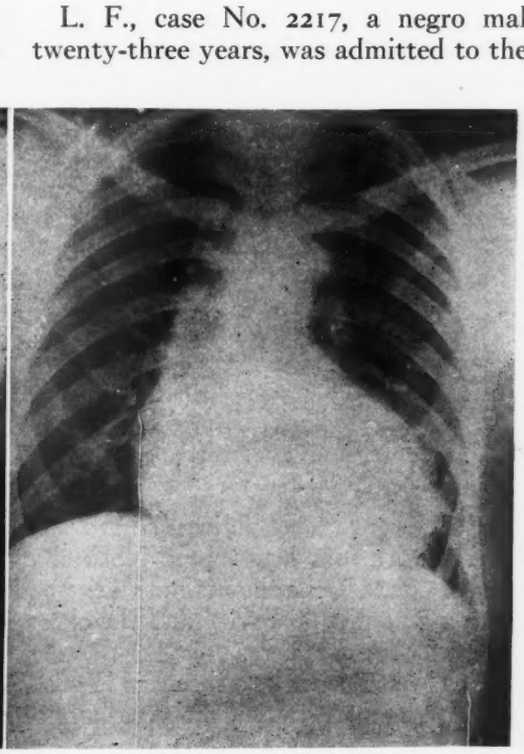

FIG. 2. Fifteen days postoperatively reveals some diminution in size of the cardiac shadow.

CASE REPORT

L. F., case No. 2217, a negro male, age twenty-three years, was admitted to the emergency room of the Passavant Hospital at 11:55 P.M. on April 7, 1944, shortly after being stabbed in the left chest with a pocket knife.

A sucking wound was present in the sixth interspace about two inches lateral to the left sternal border. His clothes were bloodsoaked and radial pulse and blood pressure were unobtainable. An intravenous infusion of 5 per cent glucose in saline solution was started and the patient taken to the operating room.

Under local infiltration anesthesia the knife wound was débrided and the incision extended along the sixth interspace with section of the fifth, sixth and seventh costal cartilages close to the sternum. A hemothorax was encountered

and emptied by mechanical suction. A spurting laceration of the heart muscle, near the apex was closed with two interrupted black silk

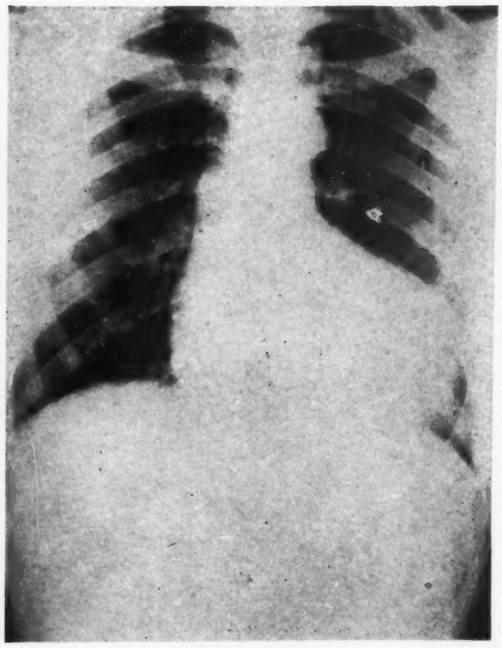

Fig. 3. Examination on discharge, twenty-eight days postoperatively reveals cardiac enlargement suggestive of an aortic regurgitation.

sutures and the rent in the pericardial sac was loosely closed with four interrupted black silk sutures. Five Gm. of sulfanilamide powder was sprinkled into the pleural cavity and the chest wall closed without drainage.

The patient was returned to the ward in good condition and sulfadiazine, Gm. 1, administered every four hours for ten days.

On April 15, 1944, a chest *x*-ray (Fig. 1) revealed "a marked enlargement of the cardiac shadow. The contour suggests fluid in the pericardium." At this time he had been complaining of a full feeling in his chest, labored respirations and dyspnea. The costoxiphoid route was chosen for pericardial aspiration and 25 cc. of straw colored fluid was obtained. In spite of this small amount of aspirated fluid he made a dramatic improvement.

On April 22, 1944, a second *x*-ray examination (Fig. 2) reported "the size of the cardiac shadow is considerably reduced since the last examination. It is possible there may still be a small amount of fluid in the pericardium." His temperature reached normal on the twelfth day and he continued to improve until his discharge twenty-eight days after his injury. An *x*-ray examination taken on his discharge (Fig. 3) demonstrated "a marked enlargement

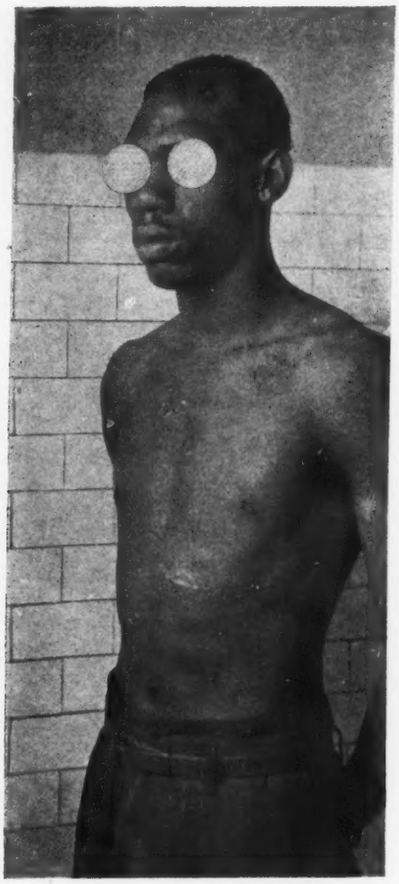

Fig. 4. Patient on discharge from hospital.

of the cardiac shadow. The left border extends out almost to the chest wall. The contour does not indicate the presence of a pericardial effusion at this time. The enlargement is mostly in the region of the left ventricle and would indicate the presence of an aortic regurgitation."

This patient's past medical history revealed an attack of rheumatic fever at fourteen years of age and anti-syphillitic treatment for some time prior to his hospital admission. On physical examination the characteristic signs of aortic regurgitation were present. The cor bovinum of aortic regurgitation made an excellent target for a knife thrust at the left chest wall. His prompt recovery and return to his former occupation without any signs or symptoms referable to his accident attests to the ability of even the heart scarred by disease to withstand surgery due to *penetrating trauma.*

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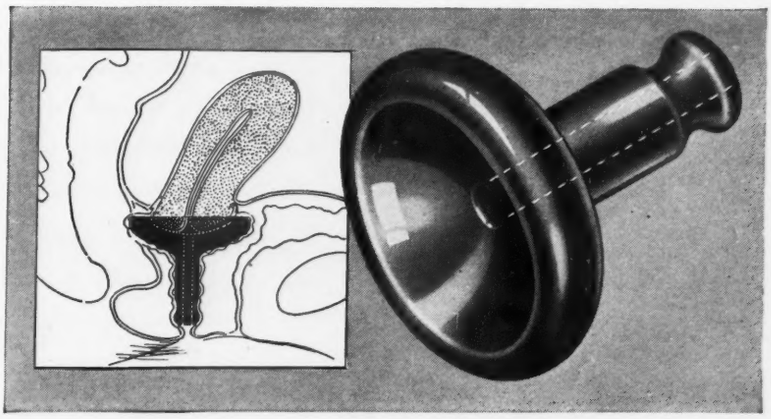

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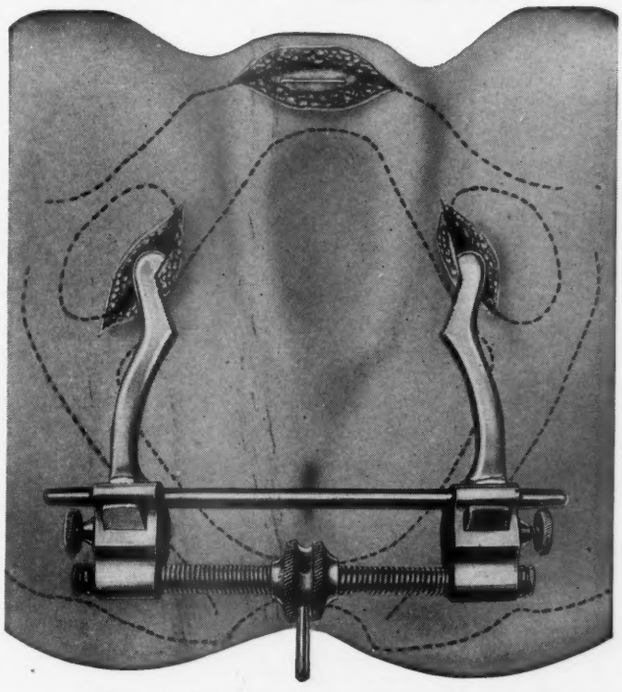

The increasing frequency and severity of pelvic fractures due to automobile and industrial accidents makes this tractor an indispensable addition to the surgeon's required instruments. Especially so are the far reaching effects of these fractures when they involve the female pelvis.

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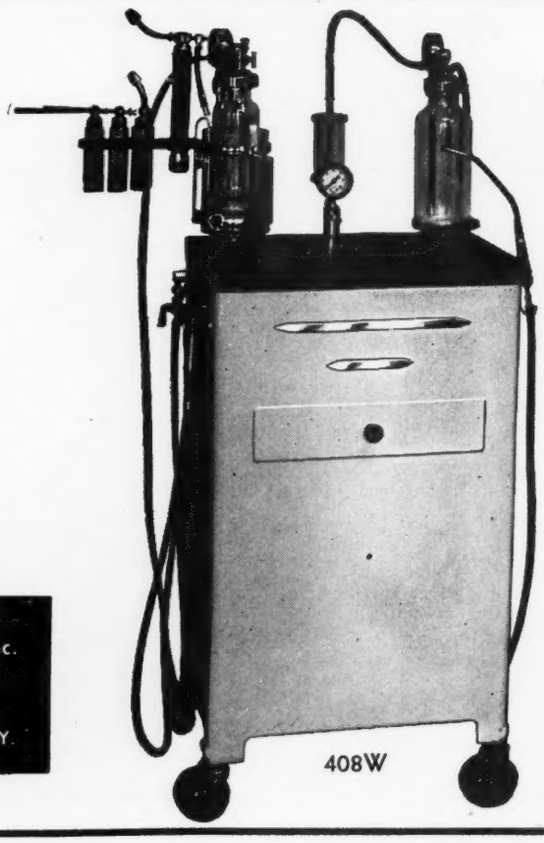

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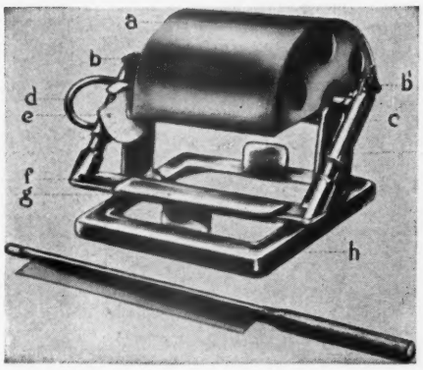

By means of this unique instrument a sheet of skin of uniform thickness may be cut at any predetermined level the size of the drum (4 x 8 inches) from any area of the body. Those who have used the dermatome state that it simplifies the technique and enlarges considerably the whole field of skin grafting. Same blade used for drum may be placed in handle and used to cut razor grafts or for honing blade. Rubber cement for the drum and donor area also is available, as well as a knife sharpening service.

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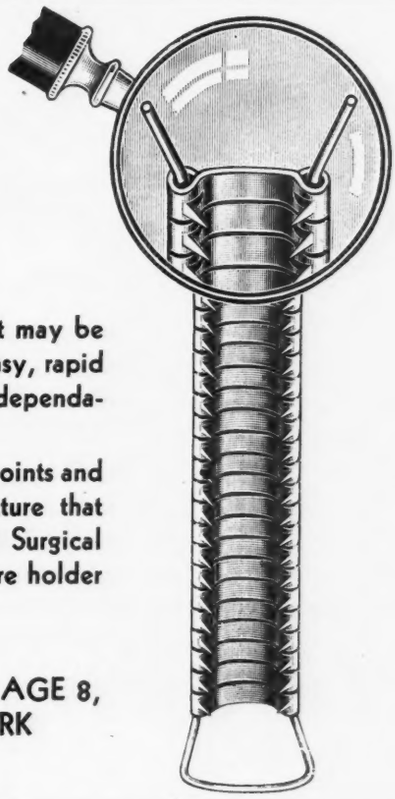
(MICHEL TYPE)



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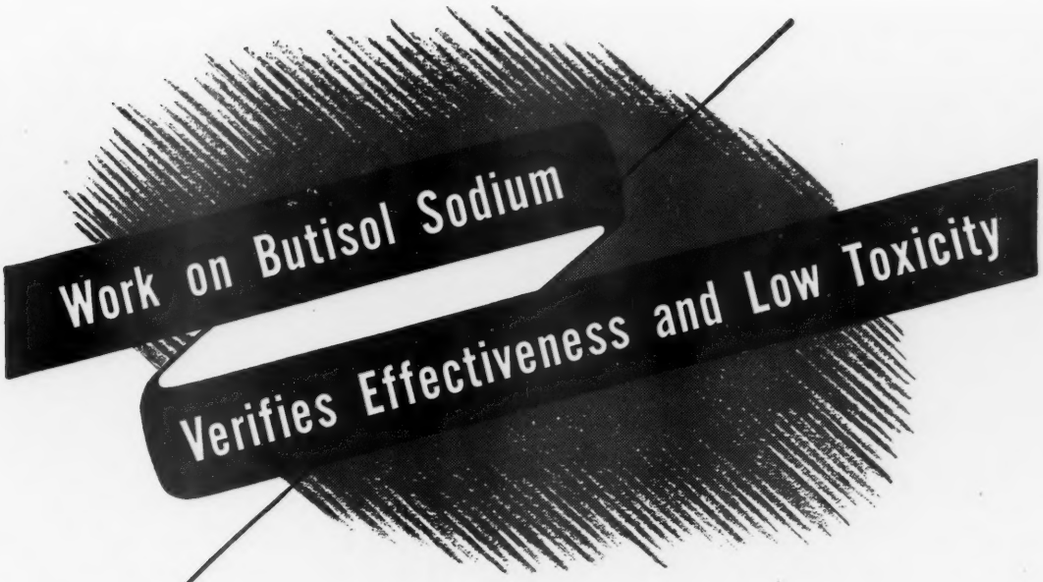

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*Gruber, C. M., Ellis, F. W. and Freedman, G. J. Pharmacol. & Exper. Therap. *81*:254 (July) 1944

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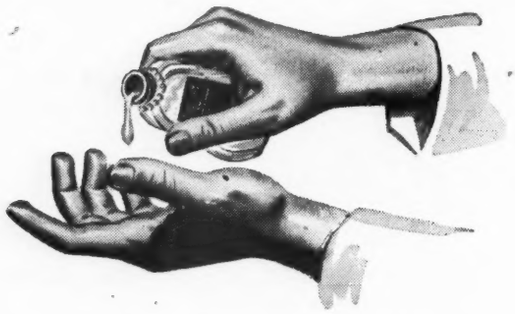
To help *prevent* rough hands caused by frequent washing



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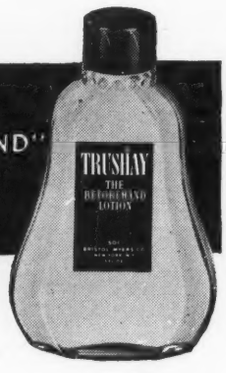

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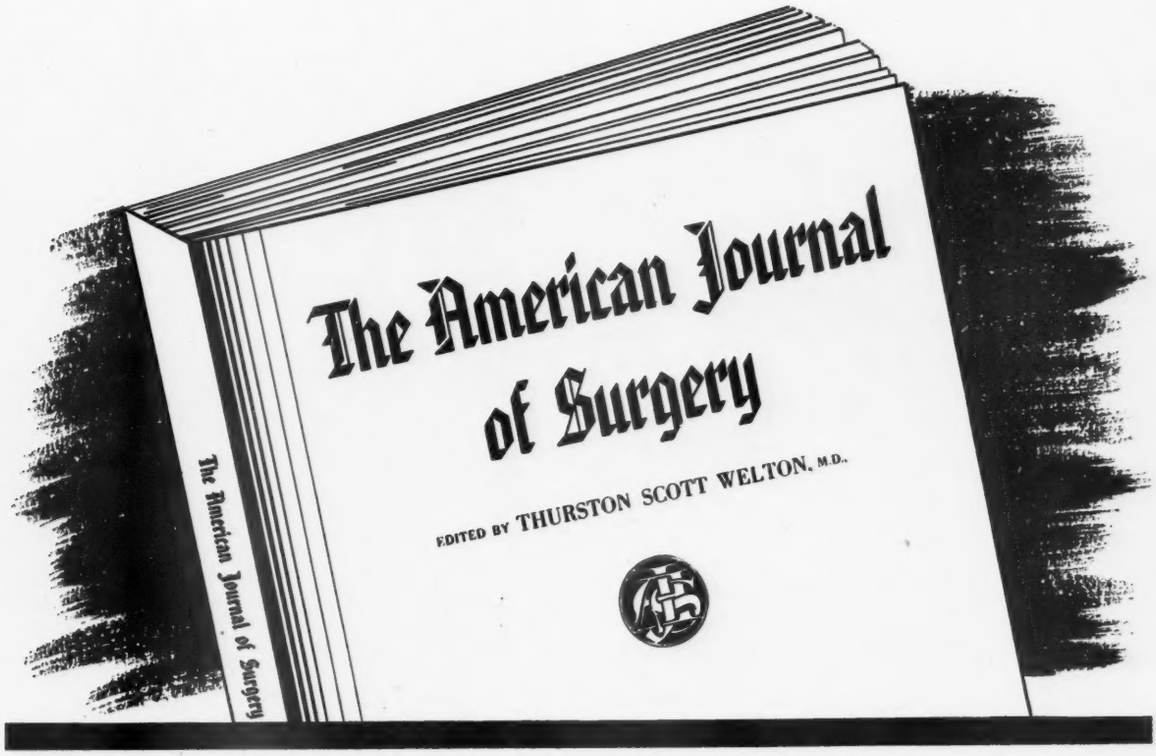

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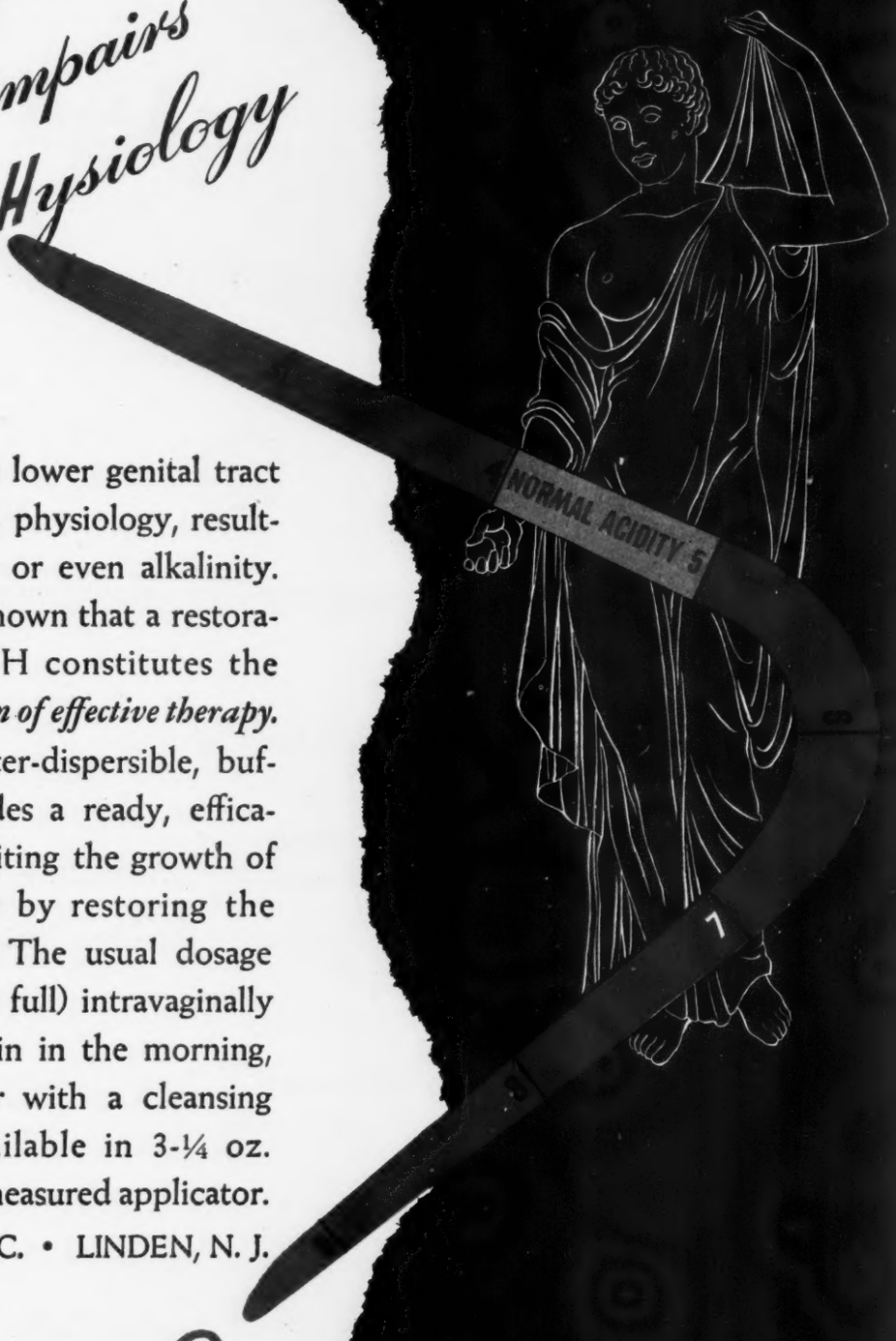
When infection impairs Vaginal pHysiology



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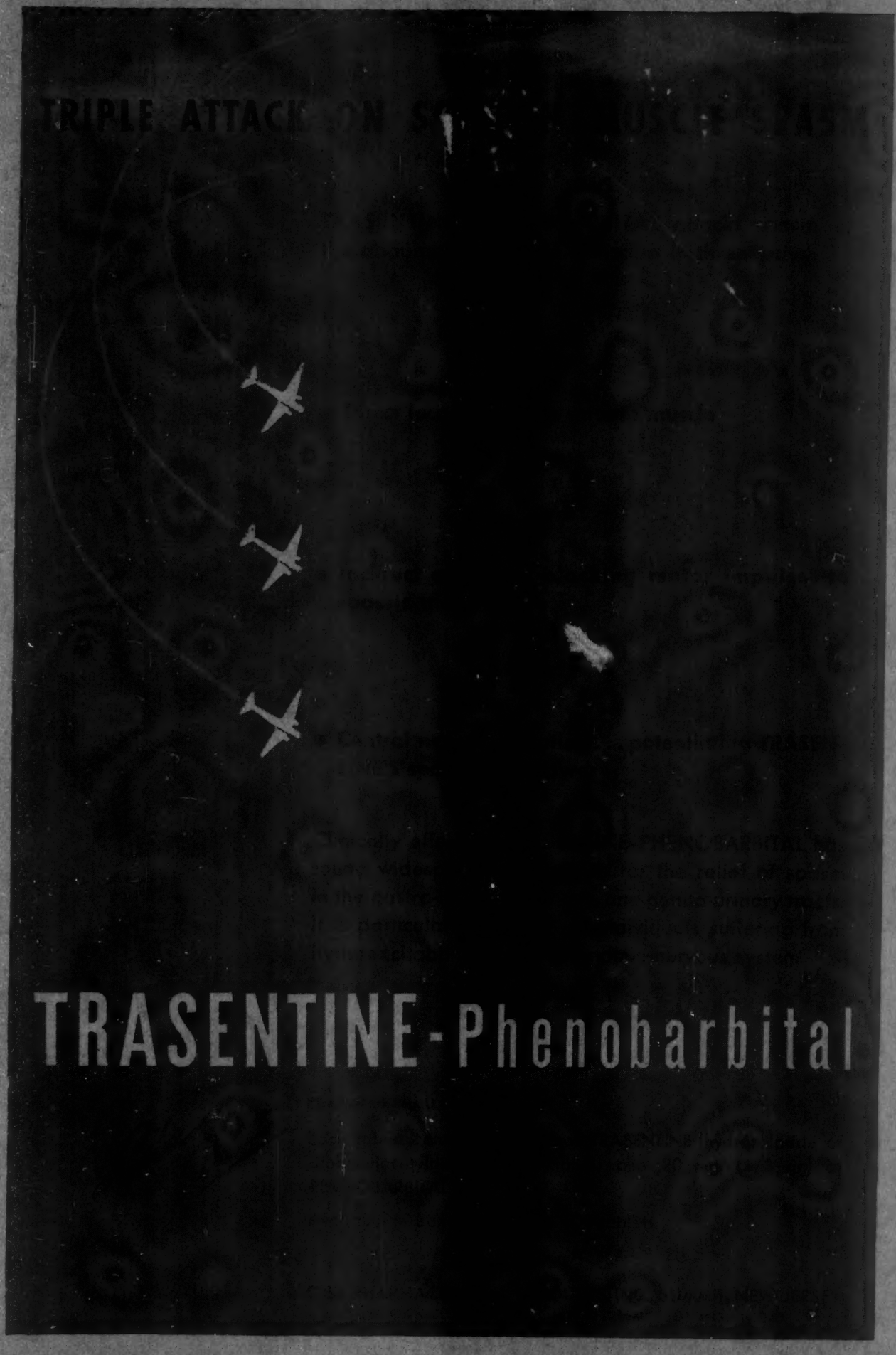
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